EXpedite the PRocessing of Experiments to Space Station (EXPRESS) Rack Payloads Interface Definition Document

International Space Station Program

August 6, 2002

Issue D

National Aeronautics and Space Administration
International Space Station Progra
Johnson Space Center
Houston, Texa
Contract No. NAS8-50000 (DR SE44)

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INTERNATIONAL SPACE STATION
INTERFACE DEFINITION DOCUMENT

EXPEDITE THE PROCESSING OF EXPERIMENTS
TO SPACE STATION (EXPRESS) RACK PAYLOADS

ISSUE D
AUGUST 6, 2002

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INTERNATIONAL SPACE STATION
INTERFACE DEFINITION DOCUMENT

EXPEDITE THE PROCESSING OF EXPERIMENTS
TO SPACE STATION (EXPRESS) RACK PAYLOADS

DR SE44
(SSP 52000-IDD-ERP)
ISSUE D

AUGUST 6, 2002

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ABSTRACT

This Interface Definition Document (IDD) provides a single source of design and interface compliance requirements which must be satisfied in order to certify and EXPRESS Rack payload for integration into an applicable EXPRESS Rack. The physical, functional, and environmental design requirements associated with payload safety and interface compatibility are included herein. This document complements the orbiter middeck IDD, NSTS 21000-IDD-MDK, and forms the basis for the payload-specific Interface Control Documents (ICD). This document covers transportation and on-orbit phases of the EXPRESS Rack payloads. This document is submitted in accordance with Letter Contract NAS8-50000, Modification 266, and Data Requirement (DR) SE44.

KEY WORDS

Design Requirements

EXPRESS Rack

Interface

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TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF FIGURES

TABLE OF CONTENTS (CONTINUED)

LIST OF FIGURES

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF TABLES

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

SECTION 1, INTRODUCTION

1.1 PURPOSE

This Interface Definition Document (IDD) defines and controls the design of the interfaces between the EXPRESS Rack facility and the payloads using the accommodations of the EXPRESS Rack (with or without Active Rack Isolation System (ARIS)) and the EXPRESS Transportation Rack. Information on the orbiter middeck is included in this document for completeness; however, it is for reference only, since it is controlled in the Middeck IDD, NSTS 21000-IDD-MDK. Payloads located in the middeck for launch or landing and moved to the EXPRESS Rack on orbit must comply with the requirements in NSTS 21000-IDD-MDK. This IDD and the payload-unique Interface Control Document (ICD), which is developed from this document, are defined below.

This IDD should be used in conjunction with the Payload Accommodations Handbook (PAH) for EXPRESS Rack Payloads, SSP 52000-PAH-ERP. The PAH describes the accommodations and capabilities of the EXPRESS Rack and associated ISS interfaces. The PAH does not levy any requirements since that is the purpose of this IDD. The requirements in this IDD will be verified in accordance with the Payload Verification Plan (PVP) for EXPRESS Rack Payloads. The PVP defines the verification methodology and data requirements for verifying each of the requirements in the IDD. The PVP does not impose any additional interface or design requirements.

1.1.1 Definition of IDD

A. Levies the associated design requirements and defines the interfaces which are provided by the EXPRESS Rack for payloads that utilize EXPRESS Rack (with or without ARIS) and EXPRESS Transportation Rack and associated EXPRESS Rack-provided accommodations.

B. Defines and controls constraints which shall be observed by members of the International Space Station (ISS), EXPRESS Rack, and the payload community in using the interfaces defined.

C. Establishes commonality with respect to analytical approaches, analytical models, technical data, and definitions for integrated analysis by interfacing parties.

D. This IDD contains data from the Middeck IDD in order to establish a common document for payloads. The middeck requirements are applicable only to the payloads that use the middeck for transportation.

1.1.2 Definition of Payload-Unique ICD

A. Defines and controls the design of interfaces (standard, nonstandard, and unique) between the EXPRESS Rack facility (with or without ARIS) and/or EXPRESS Transportation Rack and the payload.

B. Selects the IDD interfaces, and defines selectable parameters and unique interfaces between the EXPRESS Rack facility (with or without ARIS) and/or EXPRESS Transportation Rack and the specific payload. (See Appendix D.)

C. Defines and controls the constraints which shall be observed by both the EXPRESS Rack facility and/or EXPRESS Transportation Rack and the payload in using the interfaces so defined.

D. Establishes commonality with respect to analytical approaches, analytical models, technical data, and definitions for integrated analysis by both interfacing parties.

E. Development of an ICD based on this IDD will fulfill the requirements for EXPRESS Rack and Shuttle middeck. The EXPRESS Rack Office (ERO) will provide an integrated set of middeck requirements to the ISS Program for the applicable payload complement.

1.1.3 Definition of Flight-Unique Interface Control Annex (ICA)

The ICA is a document specific to the shuttle middeck accommodations, interfaces, and requirements. This document will be applicable to all of those EXPRESS Rack payloads that launch or land in the orbiter middeck and are transferred to/from the ISS on a particular flight. The ICA will:

A. Define the interfaces and resource requirements (power, volume, separate stowage items, etc.) which shall be provided by the Shuttle middeck for all payloads on a particular flight.

B. Document the exceedances to NSTS 21000-IDD-MDK specified interfaces/ requirements via approved Change Requests (CR).

The information from the payload-unique ICD will be used by the ERO to develop the necessary ICA inputs. The ICA is an integrated document that includes all applicable payload information for Shuttle middeck requirements. Additional inputs to provide information for the ICA are not anticipated at this time.

1.1.4 Waivers, Deviations, and Exceedances

Unique ICDs are derivatives of this IDD and do not require Space Shuttle Program or International Space Station Program approval if they remain within the interface design parameters defined by this document.

Any exceedance or deviation from the capabilities or services defined in this IDD shall be documented in a unique section paragraph of the derived ICD. This unique paragraph shall document the specific requirement violated, a description of the existing condition, and a rationale for acceptance. All waivers, deviations, and exceedances must be approved by the ISS Payloads Office (and the Space Shuttle Program orbiter interfaces are affected).

<u>Definitions</u>:

Exception: The general term used to identify any payload-proposed departure from specified requirements or interfaces. An exception is further classified as an exceedance, deviation, or waiver per the descriptions provided below.

Exceedance: An exceedance is a condition that does not comply with a stated IDD requirement, which is identified prior to baselining the payload-unique ICD. It exceeds the defined payload limits, but when combined with the remaining payload complement, the module/ISS limits are not exceeded, or it does not impact the performance of the remaining payload complement, and it does not impact vehicle subsystems performance. The exception can be shown to be acceptable within the framework of the standard element level analysis cycle without any unique analysis or controls.

An exceedance can be approved by the ERO or the Payload Technical Review (PTR) and documented in the payload-unique ICD. Exceedances do not require approval by a Control Board.

For example, one of the requirements is that the delta-T on the Moderate Temperature Loop (MTL) should be at least 35 ºF. If "Payload X" wishes to have a delta-T of 32 ºF, this would be classified as an exceedance. It does not exceed vehicle limits or affect safety; it only influences the efficiency of the use of the MTL.

Deviation: A deviation is a noncompliance to an IDD requirement, which is identified prior to baselining the payload-unique ICD. It is different from an exceedance in that the defined exception exceeds module/ISS limits. Additional analysis outside the scope of the standard element analysis cycle or unique operational guidelines or constraints may be needed to approve the exception. Deviations must be approved by a Control Board.

For example, one of the requirements is that the maximum return temperature of the MTL should be 120 ºF. If “Payload Y” wishes to have a return temperature of 123 ºF and their ICD has not been baselined, this would be classified as a Deviation. The vehicle is designed to accommodate return temperatures of 120 ºF or less, and special analysis must be done to determine if the vehicle can accommodate this or if operational constraints will be required.

Waiver: A waiver is a condition found in noncompliance to an IDD requirement or to the baselined payload-unique ICD, which is identified after baselining the payload-unique ICD. Typically this will occur as a result of the final as-built hardware verification program. It may require additional analysis outside of the scope of the standard element analysis cycle or unique operational guidelines or constraints to approve the exception. Waivers must be approved by a Control Board.

For example, one of the requirements is that the continuous acoustic noise must not exceed NC40. “Payload Z” has already baselined their ICD, and recent testing of the flight hardware shows that their continuous noise level is NC45. Additional evaluation will be required to determine if this can be accepted, and it may result in operational constraints.

1.2 SCOPE

The requirements defined in this document apply to the design/development, transportation, launch/landing, and on-orbit phases of the payload cycle. Transportation (to/from ISS) requirements are for payload bay-located hardware specific to the Mini-Pressurized Logistics Module (MPLM) mounted in either an EXPRESS Rack or an EXPRESS Transportation Rack. Interface definition requirements for the orbiter middeck are identified in this document; however, it must be noted that these requirements are controlled in NSTS 21000-IDD-MDK.

This IDD also identifies safety interface and design requirements with which EXPRESS Rack payloads must comply; however, the Payload Developers (PD) are still required to show compliance via the safety review process to NSTS 1700.7 and ISS Addendum, KHB 1700.7, and NSTS 18798 (Interpretation Letters). The safety implementation process is defined in NSTS 13830. Each PD is responsible for development and submittal of required safety data packages and also for the coordination and completion of each safety review via the Payload Safety Review Panel (PSRP) executive secretary. The unique payload safety hazards and associated verification data must be coordinated directly with the PSRP. The PD should provide a copy of the applicable safety data package to the ERO Engineering Integration (EI) representative.

Identification of resource requirements (i.e., power, heat load, data, video, stowage hardware items) is required to be performed and included in the payload-specific integration data files in the Payload Data Library (PDL). The requirements identified in this IDD are applicable not only to the hard-mounted (Middeck Locker (MDL)/International Subrack Interface Standard (ISIS) drawer) payload equipment but also to the stowed items as well. During the development of the payload-unique ICD and flight ICA, the specific IDD requirements applicable to payload-unique stowage items will be identified and documented.

1.3 EXPRESS RACK PAYLOAD ACCOMMODATIONS

STANDARD EXPRESS RACK PAYLOAD

Payloads that use the EXPRESS Rack will be categorized for integration purposes as “standard” or “nonstandard.” This classification is based solely upon the quantity of interfaces and the resources/services required. This classification does not imply that a payload cannot be manifested in an EXPRESS Rack; however, it does provide to the payload integrator a top level indication regarding the payload complexity and allows the integrator an opportunity to assess any impacts to the standard EXPRESS Rack payload integration template. All payloads, regardless of their design complexity, are required to support all generic integration templates as shown in SSP 52000-PAH-ERP. Standard payloads will be located in the standard 8/2 EXPRESS Rack configurations. Table 1-I defines the standard EXPRESS Rack payloads accommodations.

If the payload is not stowed in a standard MDL or in a 4-Panel Unit (PU) ISIS drawer, a standard EXPRESS Rack payload can also occupy the equivalent volume of a single/double MDL or 4-PU ISIS drawer by providing its own unique support structure and attaching to the same points an MDL or ISIS drawer would attach.

The allocation for a standard EXPRESS Rack payload for on-orbit crew time is under review (**TBD#1**). A standard EXPRESS Rack payload requires less than 12 hours of crew training time. Provisions for a certain limited quantity of middeck late access and early removal are under consideration for standard EXPRESS Rack payload, but these have not been finalized yet (**TBD#2**).

TABLE 1-I STANDARD EXPRESS RACK PAYLOAD (Sheet 1 of 2)

DISCIPLINE	STANDARD ACCOMMODATION	NOTES/REMARKS
Structural/ Mechanical	Includes as a minimum: • MDL (single & double) or equivalent volume • Standard 4-PU ISIS drawer or equivalent volume	• Reference Notes 2, 3, 4, 6, and 7 • Must conform with mass, Center of Gravity (CG), frequency & volume limits. • Container to be flight qualified/certified.
Electrical/Power	• 0 W - 500 W per single MDL or 4-PU ISIS drawer position	• Reference Notes 1 & 2 • EXPRESS Rack to provide interfacing connectors and cables. • Racks in the MPLM will not be powered for ascent/descent.
Thermal Control/Cooling	• Ducted cooling via Avionics Air Assembly (AAA) is ≤200 W per payload position for MDL and <100 W for ISIS drawers. • Ducted air available to all payloads. • Water cooling via the moderate temperature water loop is 500 W per payload position. • Two payload interfaces available for water.	• Reference Notes 1, 2, & 5 • Water can be used in MDL or ISIS drawers. • Use of cabin air for cooling is restricted. • EXPRESS Rack to provide interfacing Quick Disconnects (QDs) & fluid lines. • ISS qualified/certified coldplates can be used.
Nitrogen	• One interface available for payloads (must be shared).	• Reference Notes 1 & 2 • Resource limited to 0-12 lbm/hr. • EXPRESS Rack to provide interfacing QDs and fluid lines.
Vacuum Exhaust	• One interface available for payloads (must be shared).	• Reference Notes 1 & 2 • Resource limited to achieving 1×10^{-3} torr in 2 hr. • EXPRESS Rack to provide interfacing QDs and fluid lines. • Waste gas and trace contaminants must be within EXPRESS Rack Payloads PAH/IDD table of exhaust constituents or must have been previously approved.
Control/Data	Interfaces available for each payload position include: • RS-422 • Ethernet • 5 Vdc discrete	• Reference Notes 1 & 2 • EXPRESS Rack to provide interfacing connectors and cables. • MDL positions have 3 discretes and 2 analogs.

TABLE 1-I STANDARD EXPRESS RACK PAYLOAD (Sheet 2 of 2)

DISCIPLINE	STANDARD ACCOMMODATION	NOTES/REMARKS
Control/Data (Continued)	• ±5 Vdc analog	• ISIS drawer positions have 2 discretes and 1 analog.
Video	• NTSC RS170A interface for each payload position.	• Reference Notes 1 & 2 • EXPRESS Rack to provide interfacing connectors and cables except for the payload video source or camera and its cabling. • Video compression is not available in the standard 8/2 EXPRESS Rack. • EXPRESS Rack has only one video interface to ISS.
Software	• EXPRESS Rack laptop to be shared by all payloads.	• Software is resident on a payload processor or EXPRESS Rack laptop only. • Any software which interfaces with the ISS has to be verified by the Payload Software Integration and Verification/Facility (PSIV/F). • Payload-unique application software and icons are PD developed and verified. • Computer is an IBM 760XD and uses Windows NT operating system and Microsoft Visual Basic and C++ for the Graphical User Interface (GUI).

NOTES:

1. These resources/accommodations are limited in quantity and will have to be timelined to eliminate conflicts and/or incompatibilities.
2. The utilization of this interface must be within the EXPRESS Rack accommodations as defined in the EXPRESS Rack PAH and compliant with the design and interface requirements specified in this IDD.
3. The maximum payload weight includes the payload and either the ISIS drawer or the locker shell, locker trays, and protective provisions, such as dividers, bungees, or vibration isolation foam.
4. A PU is 1.75 in.
5. Active/forced air cooling (fan in the MDL or ISIS drawer) is the responsibility of the PD.
6. Standard EXPRESS Rack payloads should not have stowage items external to the payload item(s). Stowage hardware external to the payload items(s) must be identified in the Configuration Data Set per the International Space Station Program (ISSP) submittal schedules.
7. Payloads that are microgravity sensitive can only be accommodated in ARIS-equipped EXPRESS Racks.

NONSTANDARD EXPRESS RACK PAYLOAD ACCOMMODATIONS

Payloads with requirements exceeding standard EXPRESS Rack allocations shown in Table 1-I are “nonstandard.” Payloads with requirements for resources/interfaces not offered by the standard EXPRESS Rack configurations are also “nonstandard.” This determination is dependent on the type of exceedance of the standard allocation or complexity of the unique interface. These payloads can be integrated into the EXPRESS Rack. The “nonstandard” payloads may be limited in manifesting possibilities or may necessitate alteration of the standard EXPRESS Rack payload analytical/physical integration template(s) shown in SSP 52000-PAH-ERP.

These interfaces/services listed in Table 1-I are limited in quantity (i.e., water, vacuum exhaust, GN_2) in the standard EXPRESS Rack configurations and may not be available on the earliest increment. These items may include, but are limited to, requirements for the following:

A. Specific payload location requests in the orbiter or ISS. These may not be available on the earliest increment.

B. Weight/volume/ CG/frequency not meeting the requirements specified in this document.

C. Specific environmental conditions (i.e., temperature, microgravity, etc.).

D. Complexity of experiment-to-experiment interconnectivity.

E. Crew time resources exceeding **TBD#1** hr of accumulative, noncontiguous time on orbit during the increment.

F. Crew training time exceeding 12 hours total.

There are services and/or special requests which may require the EXPRESS Rack PD to identify interfaces/requirements or supply information/data at specific times to the ISS and/or the orbiter for use in further assessments, analyses, or development of data products. These include, but are not limited to, unique interfaces, middeck late installation, middeck early removal, specific/unique microgravity environments, and crew training activities. Payloads that have “nonstandard” interfaces must contact the payload integrator as soon as possible to discuss the request.

Requests for a specific location will be entertained, although on any flight, the ISS reserves the right to assign locations to payloads mounted on an adapter plate(s) and payloads stored within standard lockers or ISIS drawers.

1.3.1 Precedence

The order of precedence of documents identified herein shall be as follows: NSTS 1700.7 and ISS Addendum, KHB 1700.7, EXPRESS Rack and middeck IDDs, unique EXPRESS Interface Agreement (EIA), payload ICDs, flight-unique ICAs, payload-specific PDL data files, Government specifications, Government standards, military (MIL) specifications, MIL standards, contractor specifications, contractor standards, and other documents.

1.3.2 Effectivity

Unless otherwise specified, the interfaces defined and controlled herein are applicable to the operational configuration of the ISS.

1.4 CHANGE POLICY

All changes to this document shall be controlled in accordance with the procedures prescribed herein and by SSP 41170, Configuration Management Requirements. Dispositioned changes shall reflect program decisions and will record new, changed, and/or deleted requirements.

1.5 DOCUMENTATION TREE

The documentation tree is shown in Figure 1-1.

1.6 TECHNICAL POINT OF CONTACT

Name	Organization	Discipline	Phone/Fax/Email
Dan Jett	MSFC/EXPRESS Rack Office (ERO) Integration Mail Code: JB29	Book Manager and EPIM Lead	(256) 961-1546 (256) 544-4966 dan.jett@tbe.com

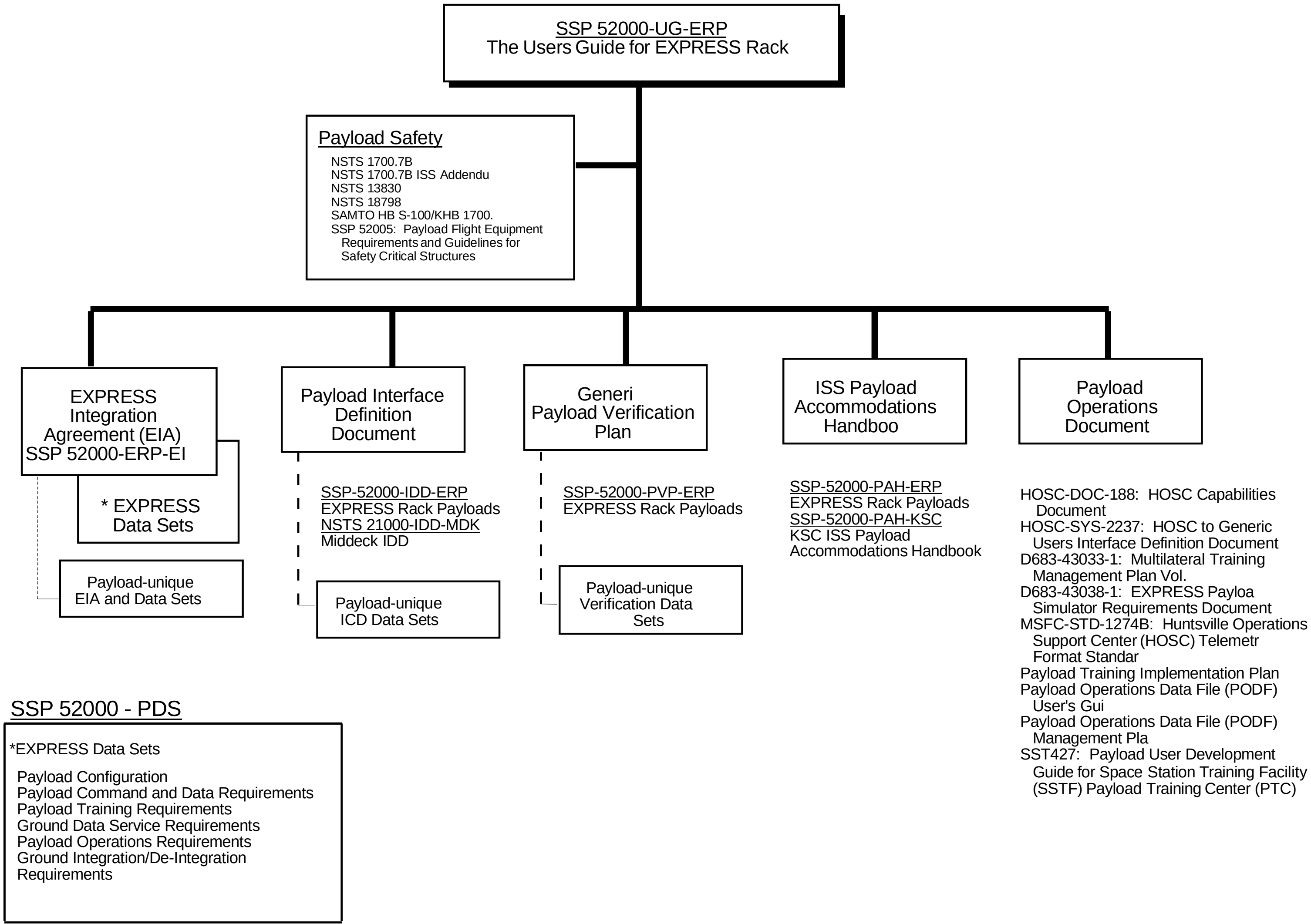

FIGURE 1-1 CUSTOMER DOCUMENTATION TREE (DRAFT) FOR EXPRESS RACK PAYLOADS

SECTION 2, DOCUMENTS

2.1 APPLICABLE DOCUMENTS

The following documents of the exact issue shown shall form a part of this document to the extent specified herein. Unless the exact issue and date are identified, the "Current Issue" cited in the contract Applicable Documents List (ADL) applies. Specific date and revision number of documents under control of the Space Station Control Board can be found in SSP 50257, Program Control Document Index or SSP 50258, Prime Control Document Index. Inclusion of applicable documents herein does not in any way supersede the contractual order of precedence. In the event of conflict between the documents referenced and the contents of this document, the contents of this document shall be considered a superseding requirement.

2.1.1 Government Documents

FED-STD-101C	Test Procedures for Packaging Materials
JSC 27199	Portable Utility Light Definition Document
JSC 27260	Decal Process Document and Catalog
JSC 27427	Requirement for Submission Test Sample - Materials Data for Shuttle Payload Safety Evaluation
JSC 36044	Space Station Mission Operations Acronyms and Abbreviations
JSC SN-C-0005, Rev. C	National Space Transportation System Specification, Contamination Control Requirements for the Space Shuttle Program
KHB 1700.7B	Space Transportation System Payload Ground Safety Handbook
MIL-A-18455	Technical Argon
MIL-C-5541C April 14, 1981	Chemical Conversion Coatings on Aluminum and Aluminum Alloys
MIL-C-26074E	Military Specification Coatings, Electroless Nickel Requirements for

MIL-STD-1189	Standard Department of Defense Bar Code Symbology
MIL-STD-1312-7	Fastener Test Methods - Method 7, Vibrations
MIL-STD-1686A	Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies, and Equipment (Excluding Electrically Initiated Explosive Devices)
MSFC-HDBK-527F/JSC 09604	Materials Selection List for Space Hardware Systems
MSFC-SPEC-250A	Protective Finishes for Space Vehicle Structures and Associated Flight Equipment
MSFC-SPEC-522B	Design Criteria for Stress Corrosion Cracking
MSFC-STD-531	High Voltage Design Criteria
NASA-STD-5003 (previously NHB 8071.1)	Fracture Control Requirements for Payloads Using the National Space Transportation System (NSTS)
NHB 5300.4 (3H)	Requirements for Crimping and Wirewrap
NASA-STD-6001 February 1998	Flammability, Odor, and Offgassing and Compatibility Requirements and Test Procedures for Materials in Environments that Support Combustion
NSTS 08242 January 4, 1988	Limitations for Non-Flight Materials and Equipment Used in and Around Space Shuttle Orbiter Vehicle
NSTS 13830B	Implementation Procedure for NSTS Payloads System Safety Requirements
NSTS 1700.7B January 1989	Safety Policy and Requirements for Payloads Using the Space Transportation System
NSTS 1700.7B, ISS Addendum December 1995	Safety Policy and Requirements for Payloads Using the International Space Station

NSTS 18798B	Interpretation of NSTS Payload Safety Requirements
NSTS 20793	Manned Space Vehicle Battery Safety Handbook
NSTS 21000-IDD-MDK, Rev. B	Middeck Interface Definition Document
NSTS 21000-IDD-486	Shuttle/Payload Interface Definition Document for the Payload and General Support Computer (PGSC)
SSP 30233E	Space Station Requirements for Materials and Processes
SSP 30237B September 30, 1994	Electromagnetic Emission and Susceptibility Requirements
SSP 30238B	Space Station Electromagnetic Techniques, General Vol. 1; Vol. 2, Requirements and Procedures
SSP 30257:004	Space Station Program Intravehicular Activity Restraints and Mobility Aids Standard Interface Control Document
SSP 30426D January 21, 1994	Space Station External Contamination Control Requirements
SSP 30512C	Space Station Ionizing Radiation Emission and Susceptibility Requirements for Ionizing Radiation Environment Capability
SSP 30573A March 22, 1994	Space Station Program Fluid Procurement and Use Control Specification
SSP 30575	Space Station Interior and Exterior Operational Location Coding System
SSP 41170	Configuration Management Requirements
SSP 50005B August 10, 1994	International Space Station Flight Crew Integration Standard (NASA-STD-3000/T)

SSP 50007 March 22, 1994	Space Station Inventory Management System Label Specification
SSP 50254	Space Station Operations Nomenclature
SSP 52000-PAH-ERP November 24, 1997	ISS Payload Accommodations Handbook for EXPRESS Rack Payloads
SSP 52000-PVP-ERP October 31, 1997	Blank Book Payload Verification Plan for EXPRESS Rack Payloads
SSP 52005A November 22, 1996	International Space Station Payload Flight Equipment Requirements and Guidelines for Safety-Critical Structures
SSP 52052-IDD-PCS	Interface Definition Document (IDD) for the ISS Portable Computer System (PCS)

2.1.2 Non-Government Documents

ANSI Z136.1-1993	American National Standard for Safe Use of Lasers
IEEE 802.3	Institute of Electrical and Electronic Engineers 802.3 (Ethernet) Standard, Carrier Sense Multiple Access with Collision Detection (CSMS/CD) Access Method and Physical Layer Specification Type 10BASE-T
SMPTE 170M	Composite Analog Video Signal - NTSC for Studio Applications
TIA/EIA-422B	Electrical Characteristics of Balanced Voltage Digital Interface Circuits

2.2 BOEING DRAWINGS AND SPECIFICATIONS

All part numbers listed in this IDD beginning with prefixes V602-, V646-, V070-, or V733- and all specification numbers beginning with the letters MA, MC, MD, or ME are Boeing documents that pertain to drawings peculiar to the specific middeck payloads.

2.3 INTERNATIONAL LATEX CORPORATION (ILC) DRAWINGS

All part numbers listed in this IDD beginning with the number(s) 10108-XXXXX are ILC drawings.

2.4 BOEING DEFENSE AND SPACE GROUP DRAWINGS

All part numbers listed in this IDD beginning with the number(s) 683-XXXXX-X are Boeing drawings or documents.

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SECTION 3, PHYSICAL AND MECHANICAL INTERFACES

3.1 GEOMETRIC RELATIONSHIPS

3.1.1 Crew Module (CM) Coordinate System

The CM coordinate system is shown in Figure 3-1 and described as follows:

Origin: In the CM plane of symmetry, 200 in below the CM reference plane and at CM X station = 0.

Orientation: The X_{cm} axis is in the CM plane of symmetry, parallel to and 200 in below the CM reference plane. Positive sense is from the nose of the vehicle toward the tail. The Z_{cm} axis is in the CM plane of symmetry, perpendicular to the X_{cm} axis positive upward in landing attitude.

The Y_{cm} axis completes a right-hand system.

Characteristics: Rotating right-handed Cartesian. The standard subscript is CM (e.g., X_{cm}).

3.1.2 International Standard Payload Rack (ISPR) Coordinate Systems (Limited Effectivity)

The ISPR coordinate system in any ISS laboratory or MPLM is shown in Figure 3-2 and described as follows:

Origin: Located at the intersection of the rack static envelope bottom, left front side and 42 in (1066.8 mm) projection from front face.

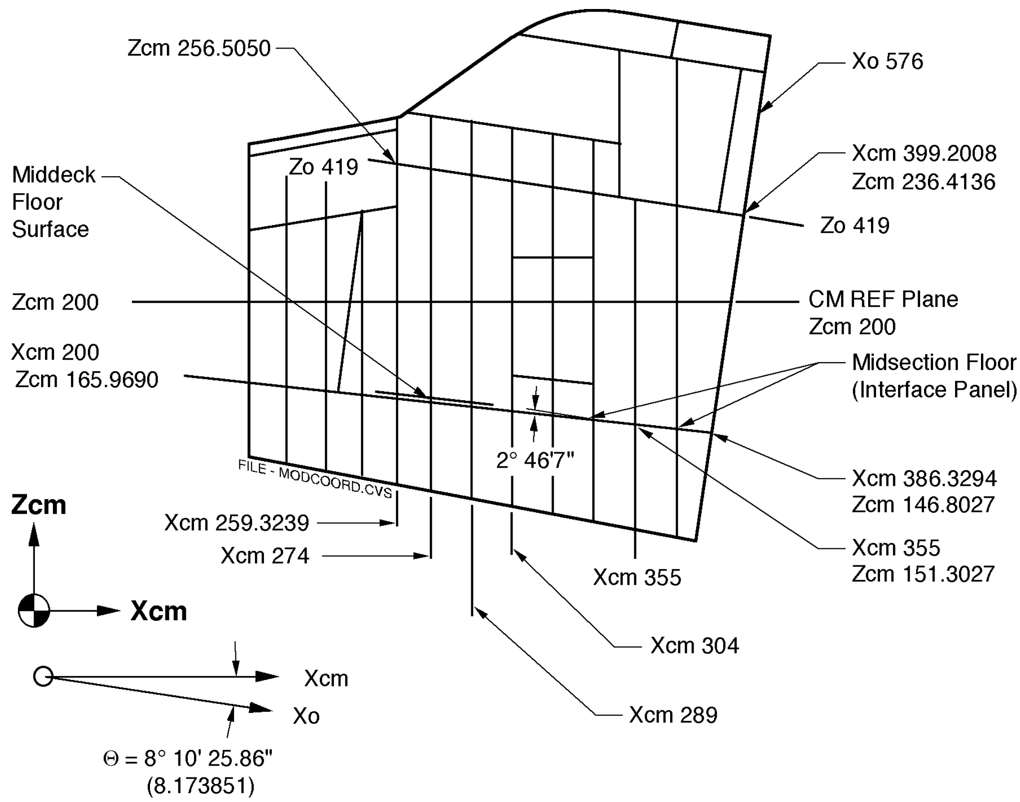
Orientation: The positive Z axis is towards the top of ISPR. The positive X axis is to the right (looking at rack), and the positive Y axis is towards the rear of the rack.

Characteristics: Rotating right-handed Cartesian. The standard subscript is ISPR (e.g., X_{ISPR}).

This section is applicable to U.S. Payloads, U.S. Bartered Payloads, and International Partner Payloads located in the U.S. pressurized volume.

3.1.3 Payload (PL) Coordinate System

The PL coordinate system is shown in Figure 3-2. It is a floating coordinate system local to each individual payload. It results from moving middeck payloads (in their original



Xo & Zo KNOWN, THEN

Xcm = COS Θ ∗ X0 + SIN Θ ∗ Zo - 230.5199739

Xcm = SIN Θ ∗ X0 + CDS Θ ∗ Zo - 96.4358496

Xcm & Zcm KNOWN, THEN

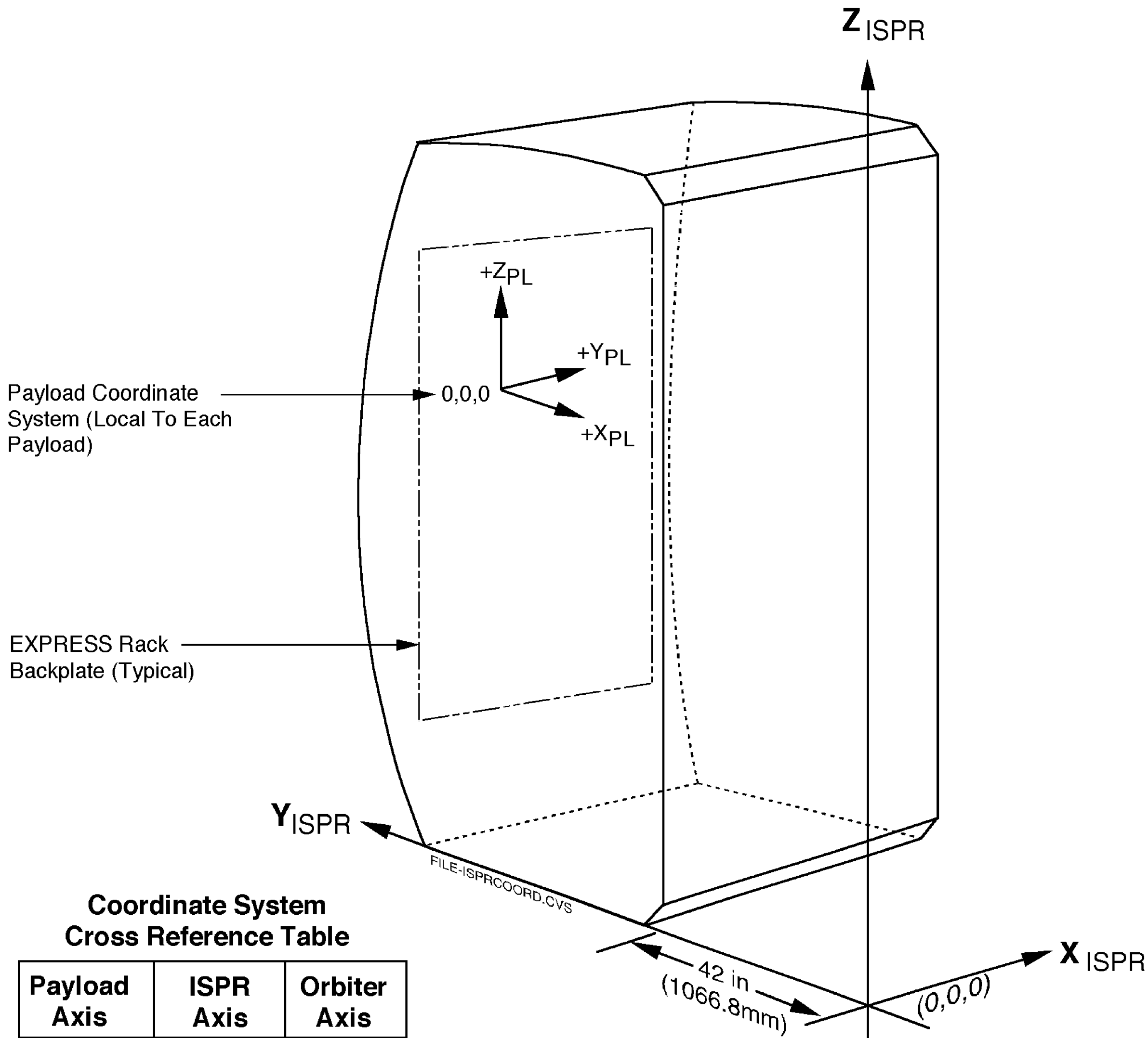
Xo = COS Θ ∗ Xcm - SIN Θ ∗ Zcm + 214.4671943

Zo = SIN Θ ∗ Xcm + CDS Θ ∗ Zcm + 128.2308622

FIGURE 3-1 CREW MODULE COORDINATE SYSTEM

CM coordinate system) to the EXPRESS Rack. It allows discussion of middeck payloads, in the coordinate system in which they were designed, in the ISPR payload orientation. It is described as follows:

Origin: The PL coordinate system origin is in the plane of the EXPRESS Rack backplate. It is a floating coordinate system located by the payload under consideration.



Coordinate System Cross Reference Table

Payload Axis	ISPR Axis	Orbiter Axis
$-X_{PL}$	$+Y_{ISPR}$	$\pm Y_{orb}$ $\pm Z_{orb}$
$+Y_{PL}$	$+X_{ISPR}$	$\pm X_{orb}$
$+Z_{PL}$	$+Z_{ISPR}$	$\pm Y_{orb}$ $\pm Z_{orb}$

FIGURE 3-2 ISPR COORDINATE SYSTEM IN THE USL (APPLICABLE TO MPLM OR ANY ON-ORBIT LAB)

Orientation:	The X_{pl} axis is toward the front of the ISPR. The Y_{pl} axis is toward the right (looking at the rack). The Z_{pl} axis is toward the top of the ISPR.
Characteristics:	Rotating right-handed Cartesian. The standard subscript is PL (e.g., X_{pl}).

3.2 DIMENSIONS AND TOLERANCES

Unless otherwise specified, all linear dimensions are in inches, all angular dimensions are in degrees, and the tolerances for these are as follows:

Decimal:	X.X	= ±0.1
	X.XX	= ±0.03
	X.XXX	= ±0.010
Fractions:		±1/16
Angles:		±0 30’

3.3 MECHANICAL INTERFACES

3.3.1 Middeck Locations

Payloads may be located in the middeck either on the aft surface of wire trays of avionics bays 1 and 2 or on the forward surface of wire trays of avionics bay 3A (reference NSTS 21000-IDD-MDK for additional details).

3.3.1.1 Avionics Bay Locations

Payloads must use the provisions in Section 3.4 to mount in avionics bays 1, 2, and 3A. Availability of specific locations for payloads use is pursuant to amount of ducted and nonducted air cooling, power required by the individual middeck payloads, mission profile and its length, the size of orbiter crew, and amount of crew equipment to be stowed in standard stowage lockers at these locations. Ducted air-cooled payloads must utilize the active air cooling orbiter outlet ducts provided in the locations shown in NSTS 21000-IDD-MDK for avionics bays 1, 2, and 3A. A single outlet duct may support either a single or double-size payload. Double-size payload location accommodations will be dependent upon avionics bay wire tray weight carrying capability at a given location.

3.3.1.2 Middeck Payload Provisions

Middeck payload mounting provisions consist of Space Shuttle Program (SSP) provided locker accommodations or mounting panels, which are defined as Payload Mounting Panels (PMP) (see Figure 3-12), Vented Payload Mounting Panels (VPMP) (see Figure 3-13), single adapter plates (see Figure 3-9), or double adapter plates (see Figure 3-10). The SSP will provide the mounting panels that interface directly to the avionics bay wire trays. EXPRESS Rack payloads transported in the orbiter middeck shall be designed to interface with the SSP mounting panels. Standard modular stowage locker accommodations consist of stowing the payload hardware in vibration isolating foam inside a standard middeck stowage tray, which is installed inside a standard modular stowage locker. The payload stowage configuration within the tray and locker is controlled by the Space Shuttle Program. Requests for SSP-provided equipment must be identified and documented in the PD EIA. The SSP-provided equipment (lockers, mounting panels, etc.) will not be transferred to the ISS.

3.3.2 ISS Locations

EXPRESS Rack payloads will be located in the EXPRESS Rack in the following areas as illustrated in Figures 3-3, 3-4 and 3-5.

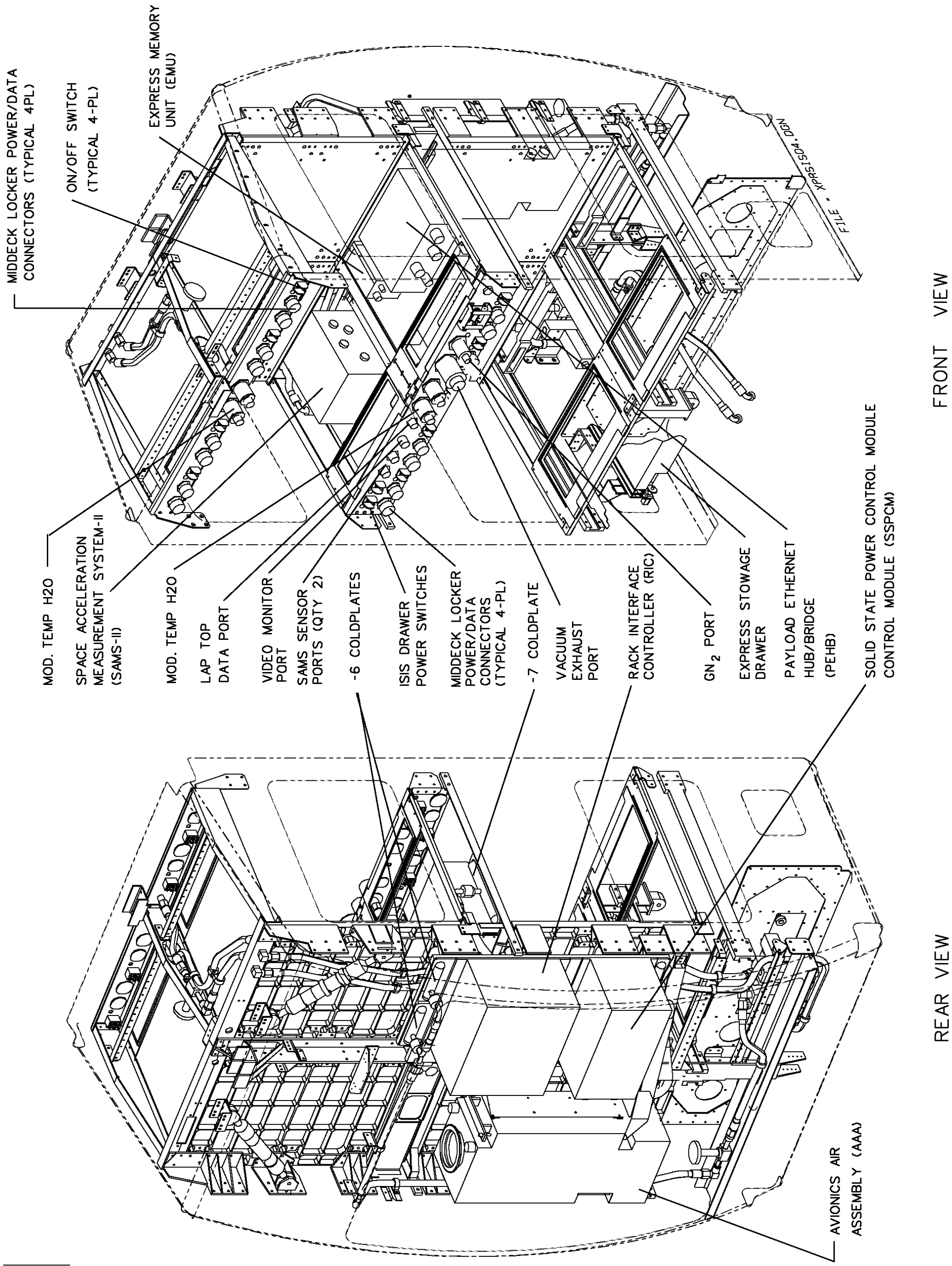
A. MDL or equivalent in an 8/2 EXPRESS Rack (Figure 3-5)

B. 4-PU ISIS drawer in an 8/2 EXPRESS Rack (Figure 3-5)

C. In ISIS drawers or MDLs in the EXPRESS Transportation Rack (Figure 3-4)

3.4 MECHANICAL PAYLOAD PROVISIONS

Payload mounting provisions consist of standard modular lockers, ISIS drawer accommodations, or mounting panels. (Note that the ISS and Space Shuttle Programs are not planning to provide mounting panels for use in the ISS). Mounting panels are defined as PMP, VPMPs, single adapter plates, or double adapter plates. If panels are used in the middeck installation, these panels will be removed from the payload prior to transfer and installation into the EXPRESS Rack. These panels will remain in the middeck location for structural support. Standard modular stowage locker accommodations consist of stowing the payload hardware in vibration isolating foam inside a standard stowage tray, which is installed inside a standard modular stowage locker. The payload stowage configuration within the tray and locker is the responsibility of the PD. Integrated stowage configuration is the responsibility of the orbiter and/or the ISS, depending on the location.



NOTE: SAMS interface available in ARIS Rack only.

FIGURE 3-3 EXPRESS RACK 8/2 CONFIGURATION EXPLODED VIEW

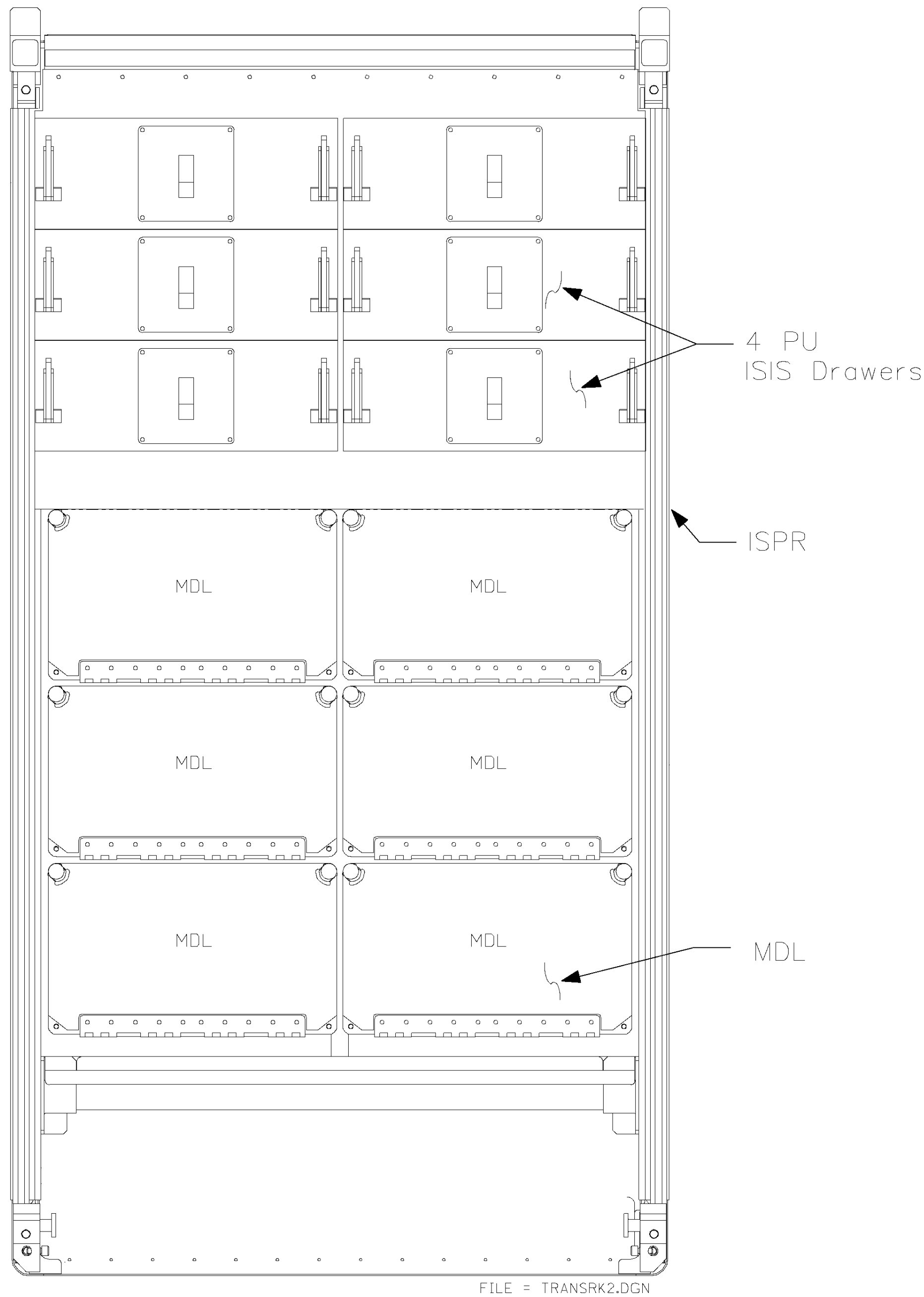


FIGURE 3-4 EXPRESS TRANSPORTATION RACK CONFIGURATION

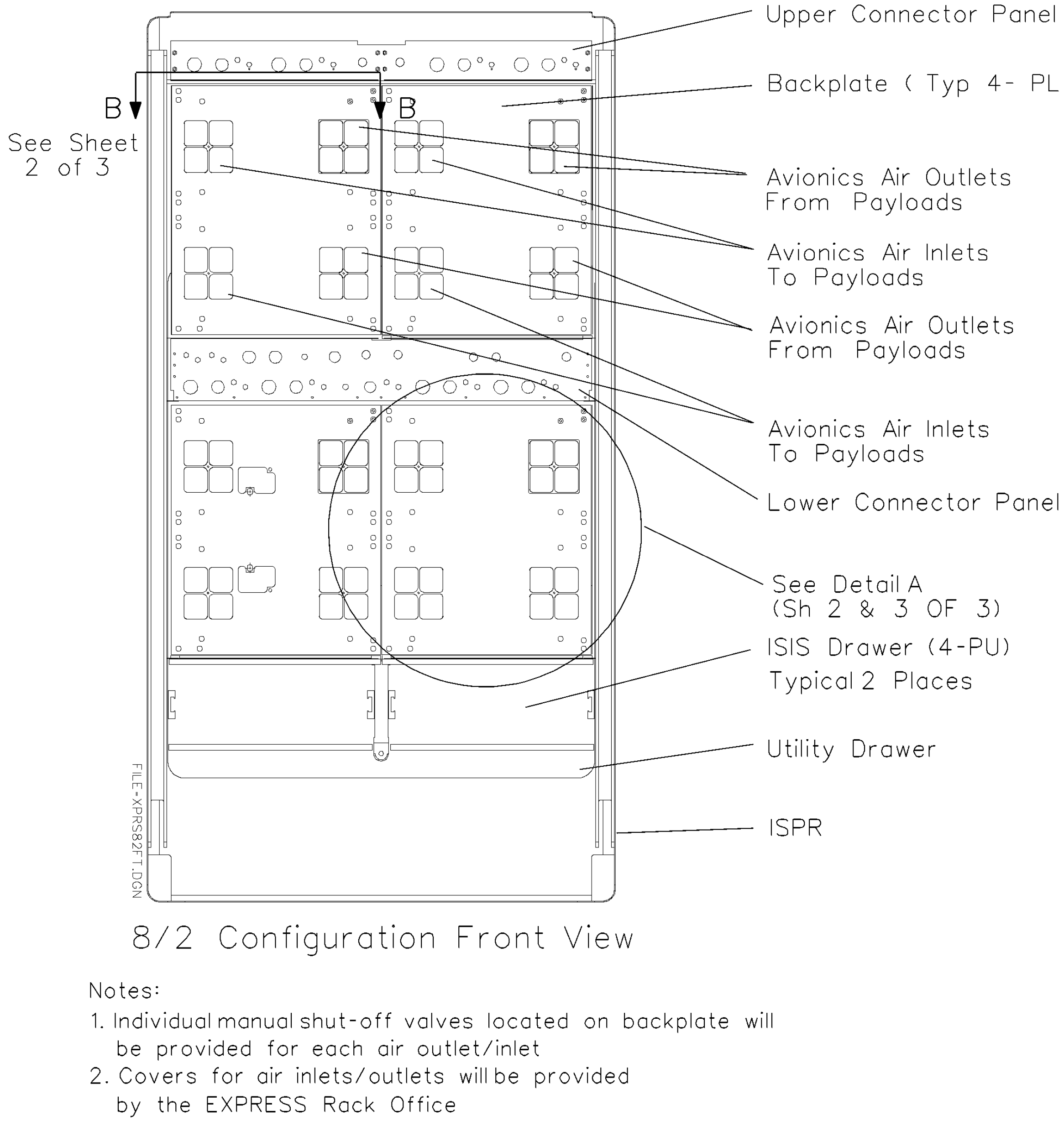


FIGURE 3-5 EXPRESS RACK 8/2 CONFIGURATION STRUCTURAL PROVISIONS FOR MDL OR MDL REPLACEMENT PAYLOADS (Sheet 1 of 3)

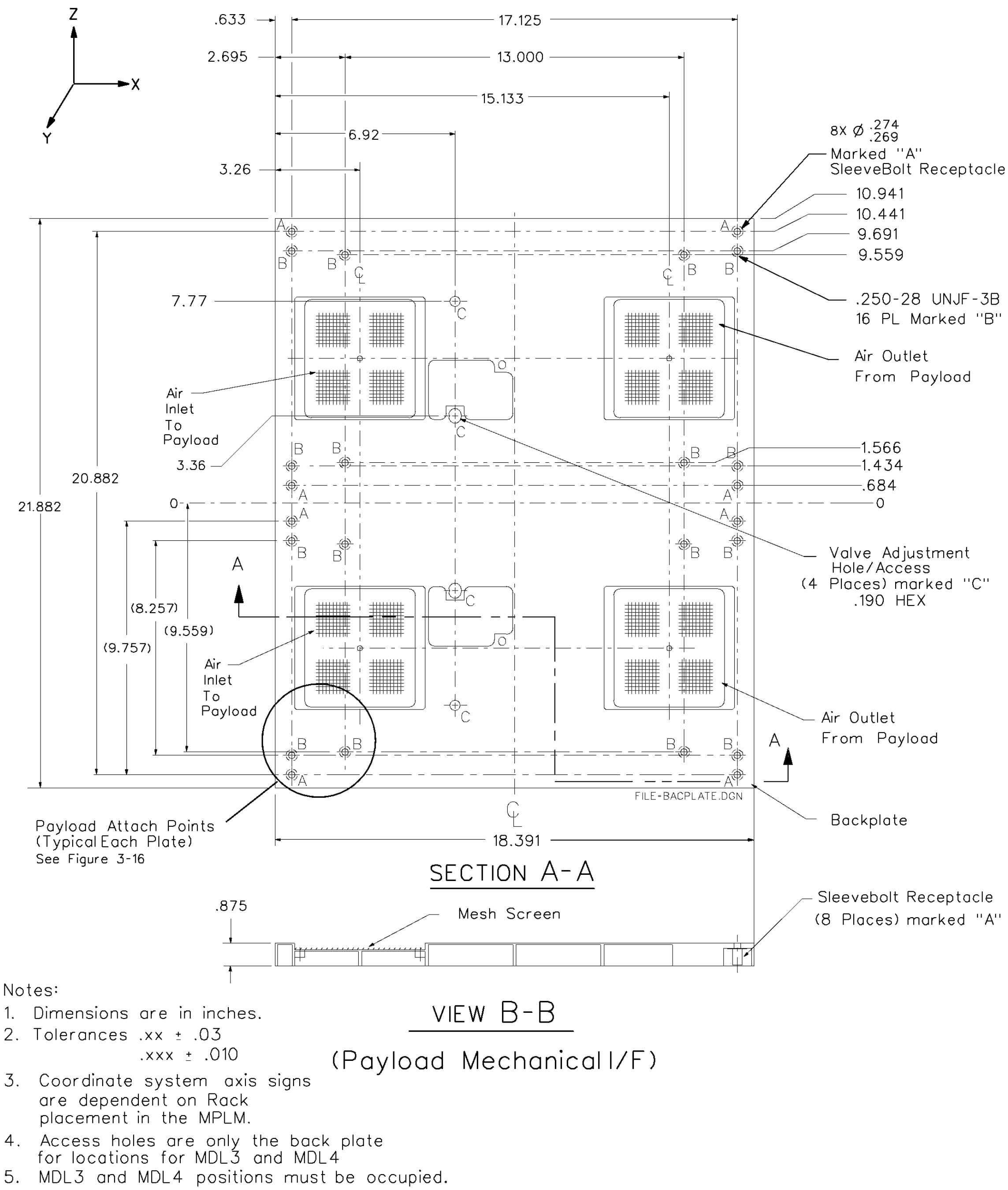


FIGURE 3-5 EXPRESS RACK 8/2 CONFIGURATION STRUCTURAL PROVISIONS FOR MDL OR MDL REPLACEMENT PAYLOADS (Sheet 2 of 3)

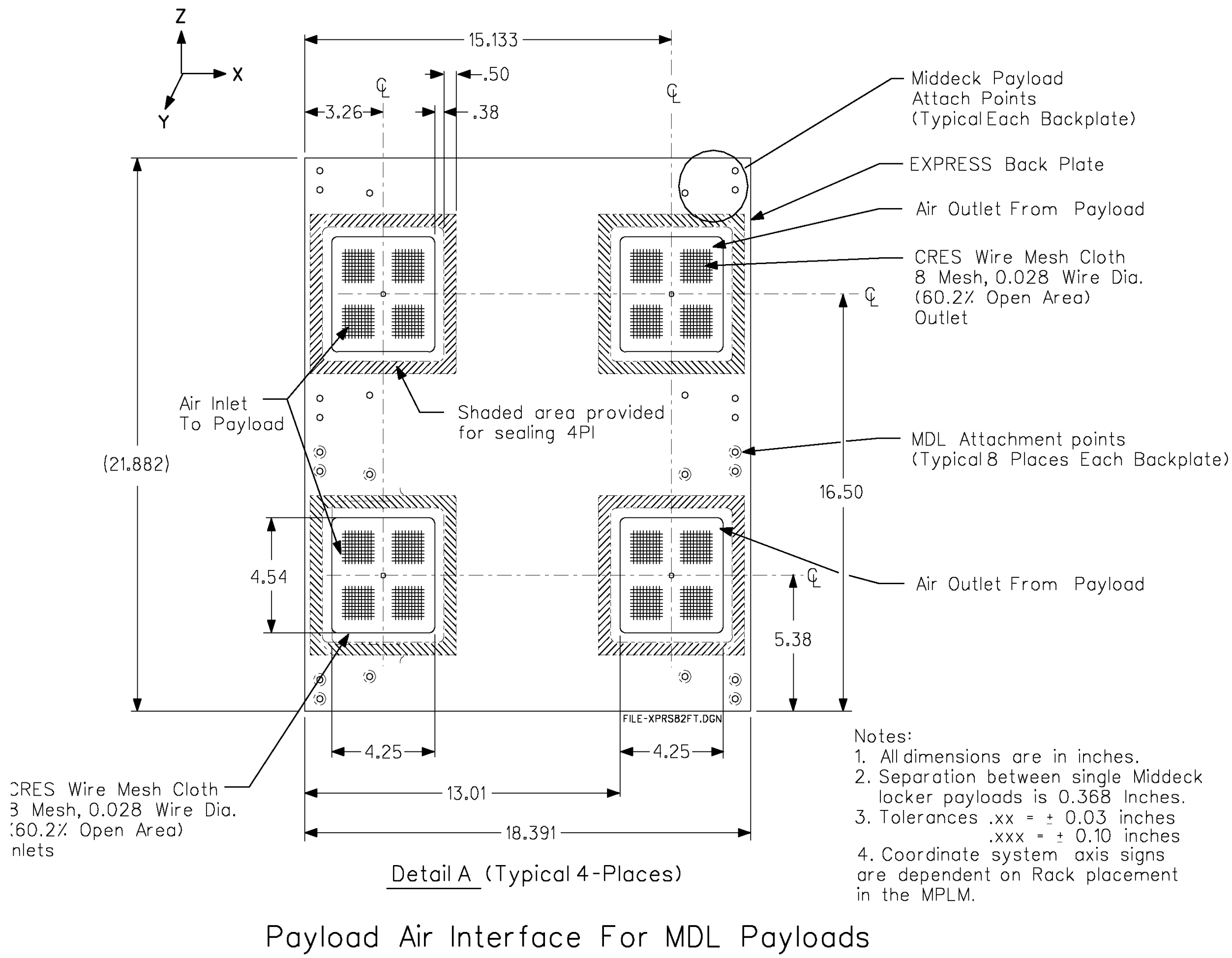


FIGURE 3-5 EXPRESS RACK 8/2 CONFIGURATION STRUCTURAL PROVISIONS FOR MDL OR MDL REPLACEMENT PAYLOADS (Sheet 3 of 3)

3.4.1 EXPRESS Mounting Plates

3.4.1.1 8/2 EXPRESS Rack Mounting Plate

Payloads shall be compatible with the mechanical interfaces defined in Figure 3-5. Due to the 8/2 EXPRESS Rack's use of single-locker wide mounting panels without dimensional control between adjacent mounting panels, for launch in the 8/2 EXPRESS Rack payloads must restrict themselves to either a single- or a double-locker configuration. Quad-locker configurations must be launched in the transportation rack and transferred to an 8/2 EXPRESS Rack on orbit. Quad-locker payloads should be designed to accommodate connection to only one of the two adjacent 8/2 EXPRESS Rack mounting panels on-orbit. Note: If configurations other than these are desired, the payload integrator should be contacted to discuss these requirements. Special mounting panels should not be required to interface to the EXPRESS Rack mounting plate; however, if one is used, the mass is charged to the PD allocation. If panels are used in the middeck installation, they will be removed from the payload prior to transfer and installation into the EXPRESS Rack in the ISS.

3.4.1.2 EXPRESS Transportation Rack Mounting Plate

Payloads shall be compatible with the mechanical interfaces defined in Figure 3-5A.

3.4.2 Standard Modular Locker

Payloads which use a standard modular locker are provided approximately 2 ft^3 of volume and shall be compatible with Figure 3-6. The standard modular stowage locker has provisions for various trays (i.e., either one large stowage tray or two small stowage trays). Payloads that cannot be stowed inside trays shall be stowed directly in a locker with isolation material between the locker and the payload.

Standard modular lockers cannot be removed from the orbiter middeck on orbit. Contents will be removed from the lockers for transfer to other stowage lockers on the ISS. Standard modular lockers do not have rear-cooling provisions and may not be modified to incorporate rear-cooling provisions. Payloads requiring power, data, or cooling must modify the removable panels in the locker door for these purposes. Note: For flights UF-3 and beyond, the ISS will not allow EXPRESS Rack payloads to exchange air with the cabin through the front of the payload enclosure (reference Section 5.3.1.2).

3.4.2.1 Standard Stowage Trays

Payloads may utilize the two sizes of orbiter-supplied standard stowage trays. Large stowage trays provide 1.8 ft^3 of volume, and small stowage trays provide 0.85 ft^3 of volume,

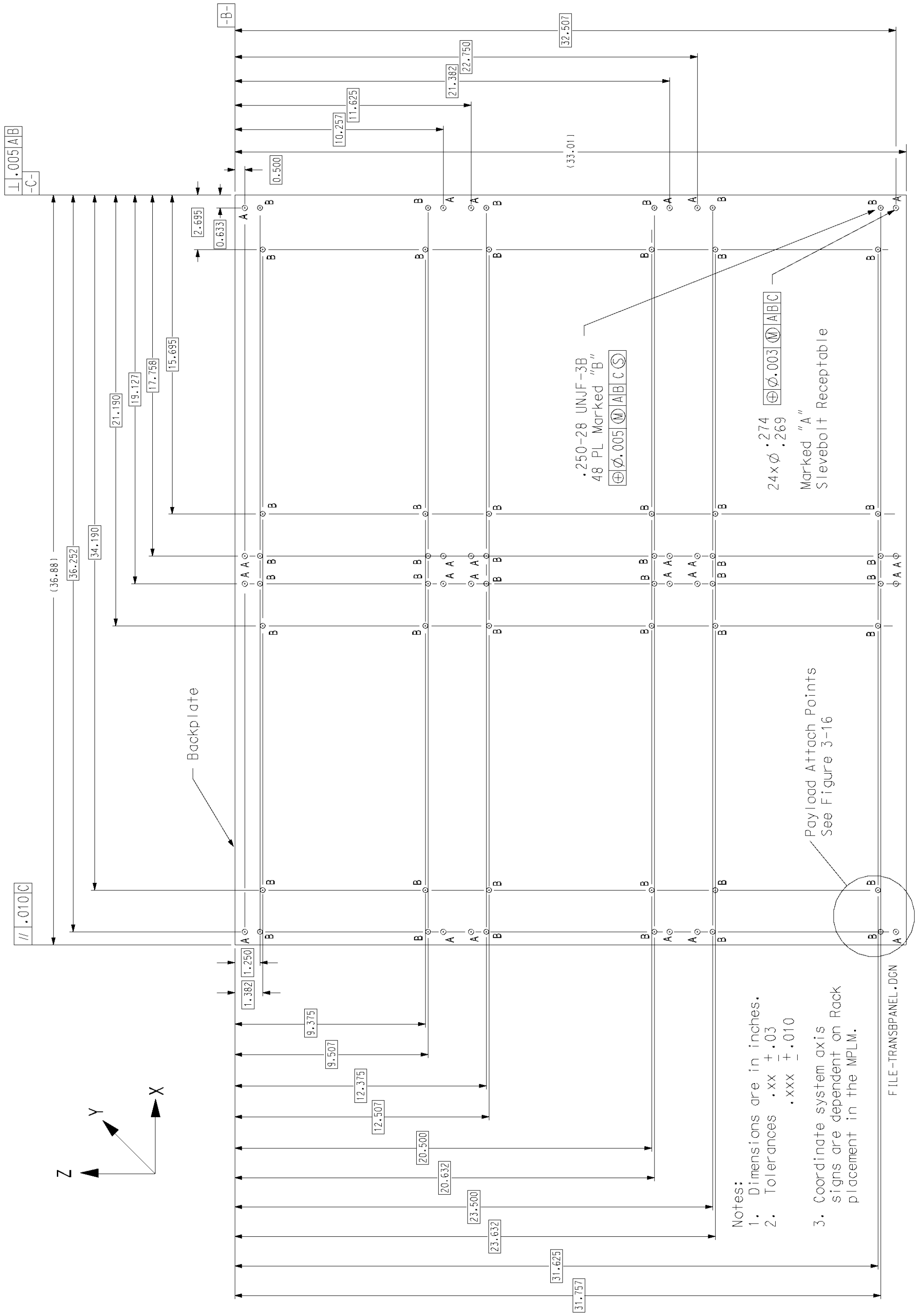
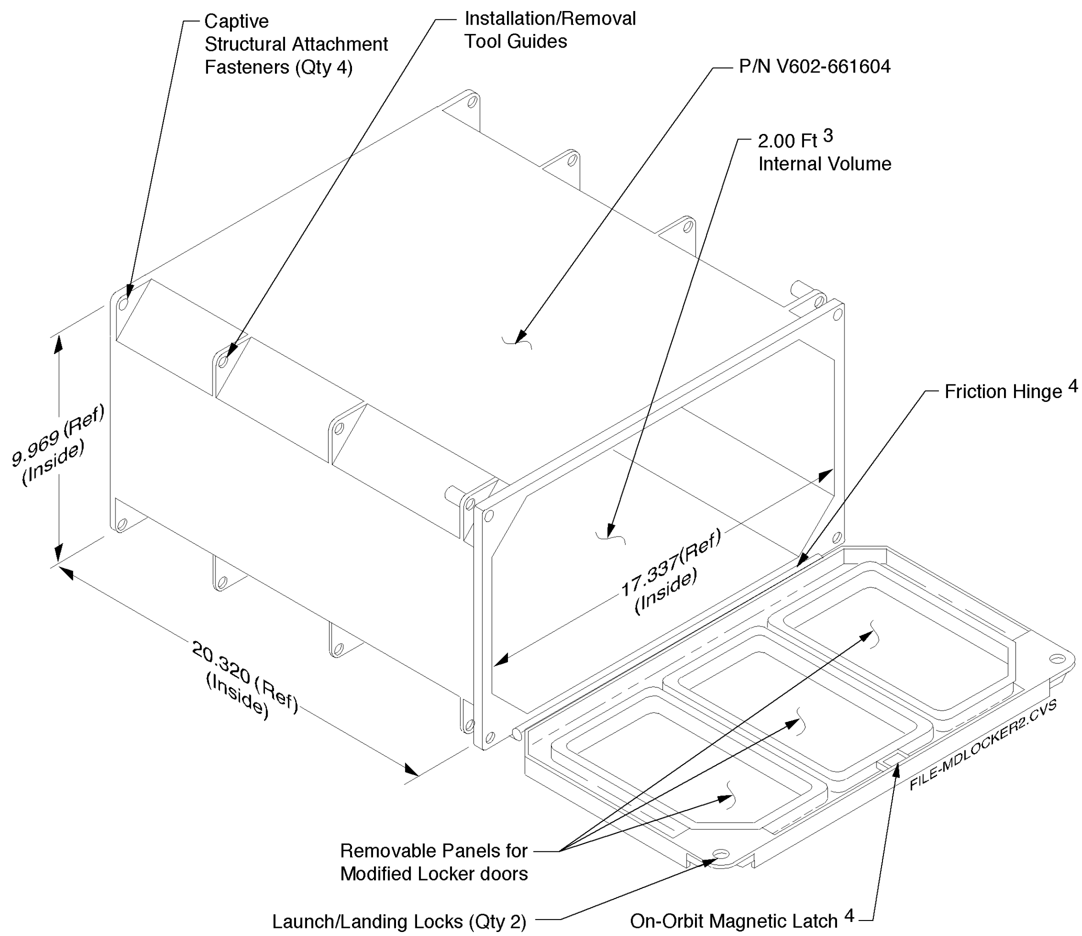


FIGURE 3-5A EXPRESS TRANSPORTATION RACK CONFIGURATION STRUCTURAL PROVISION FOR MDL OR MDL REPLACEMENT PAYLOADS



NOTES:

1. Modular locker has a maximum design density of 30 lb/ft^3, and a minimum of 10 lb/ft^3.
2. Baseline lockers are designed to the following criteria:
   – The locker is fully packed.
   – There must be isolator material (i.e., Pyrell foam or equivalent) between the locker walls and the contents. See material section on use of foam.
   – Empty locker weight is 11.8 lb (5.35 kg).
3. Door is flush with bottom of locker when opened 90º and can open 180º (straight down).
4. Door has friction hinge for zero-g operation and a magnetic latch for temporary closure of door.
5. Standard modular stowage lockers cannot be removed from the orbiter middeck on orbit.

FIGURE 3-6 STANDARD MODULAR STOWAGE LOCKER (CONTROLLED IN THE MIDDECK IDD) as shown in Figure 3-7. An empty large tray weight is approximately 3.4 lb, and an empty small tray weight is approximately 2.45 lb.

In addition to payload equipment being packaged in trays using foam inserts as described in Section 3.4, the standard stowage tray may have nonstructural plastic tray dividers dividing the tray into halves, quarters, eighths, or sixteenths. Orbiter-provided elastic restraints may be used with or without dividers to prevent equipment from floating out when lockers are opened on orbit.

3.4.2.2 Modified Locker Access Door

Payloads which are stowed inside a standard stowage locker and require access for power or cooling shall use a modified locker door. A modified locker door has three blank removable/exchangeable panels as illustrated in Figure 3-8. These blank panels are replaced with payload-unique panels on the ground prior to launch. All unique panels shall be PD supplied.

3.4.2.3 Payload Zero-G Requirements

A. The payload equipment shall have a zero-G retention feature to prevent any equipment from floating out of the tray/locker during on-orbit activities.

B. The drawer/tray shall not be jammed open or closed by these contents.

C. The drawer/tray contents shall not need a tool for removal/installation.

3.4.2.4 Isolation Material Properties

If isolation materials are used by the PD for packaging of hardware inside stowage lockers or drawers, then the isolation material (Pyrell or similar material) shall have a modulus of elasticity and thickness which will provide a spring rate of 22,000 lb/in or less (minimum thickness of 0.5 in of Pyrell compressed 25 percent would be required).

3.4.2.5 ISS-Supplied Lockers

The ISS will supply a limited number of lockers for use in the 8/2 EXPRESS Racks for ISS payloads. These lockers are intended for use in the ISS since the Shuttle-supplied middeck lockers will not be transferred into the ISS. If these lockers are used in the Shuttle middeck, the contents must be transferred. These lockers will not be removed from the Shuttle middeck wire trays once on orbit.

The ISS lockers can be configured with or without rear-breathing interfaces. Each locker is equipped with modified front doors. The locker provides its own captive locking

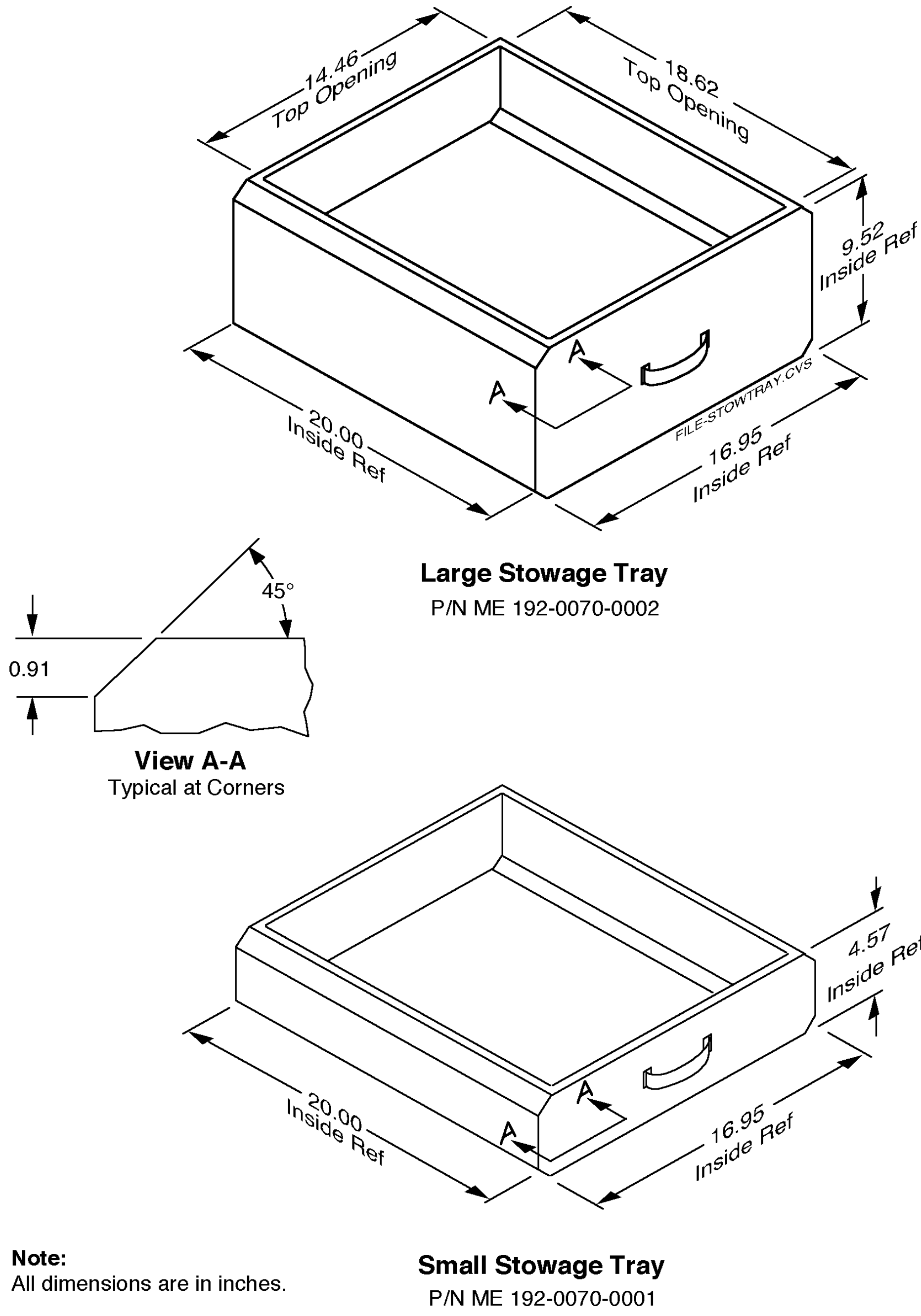


FIGURE 3-7 STANDARD STOWAGE TRAYS (CONTROLLED IN THE MIDDECK IDD)

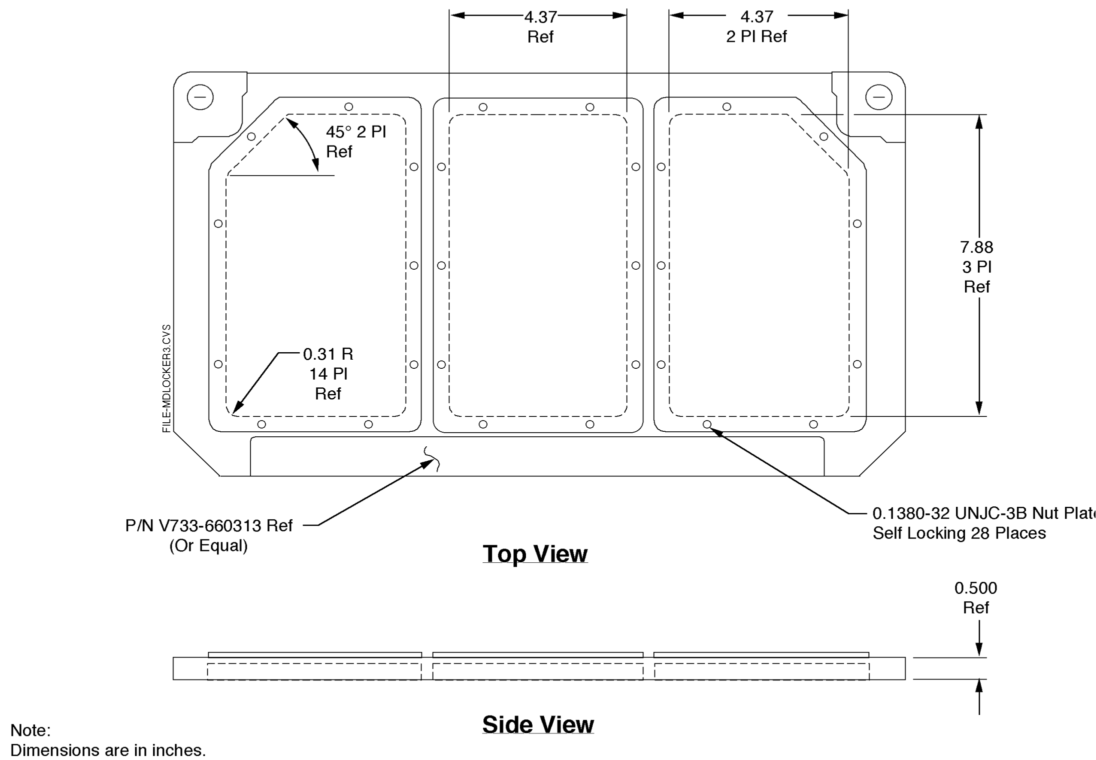


FIGURE 3-8 MODIFIED LOCKER ACCESS DOOR FOR MDL (CONTROLLED IN THE MIDDECK IDD)

fasteners to interface it with the middeck wire trays or the EXPRESS Rack backplate. There are no provisions for payload equipment to physically attach (i.e., hard mount) to the ISS locker (excluding any unique panels for the modified door). The weight of the lockers is:

Without Covers	11.0 lb
With Covers	13.0 lb

PDs must define requirements (need date, quantity, etc.) for these lockers in their payload-unique EIA. The total number of ISS lockers and their availability is under evaluation by the ISS Program.

Payloads using these lockers shall be compatible with the mechanical information shown in Figure 3-8A (Sheets 1 - 5). Note: The weight and CG requirement for payloads using this locker are documented in Section 4.4.

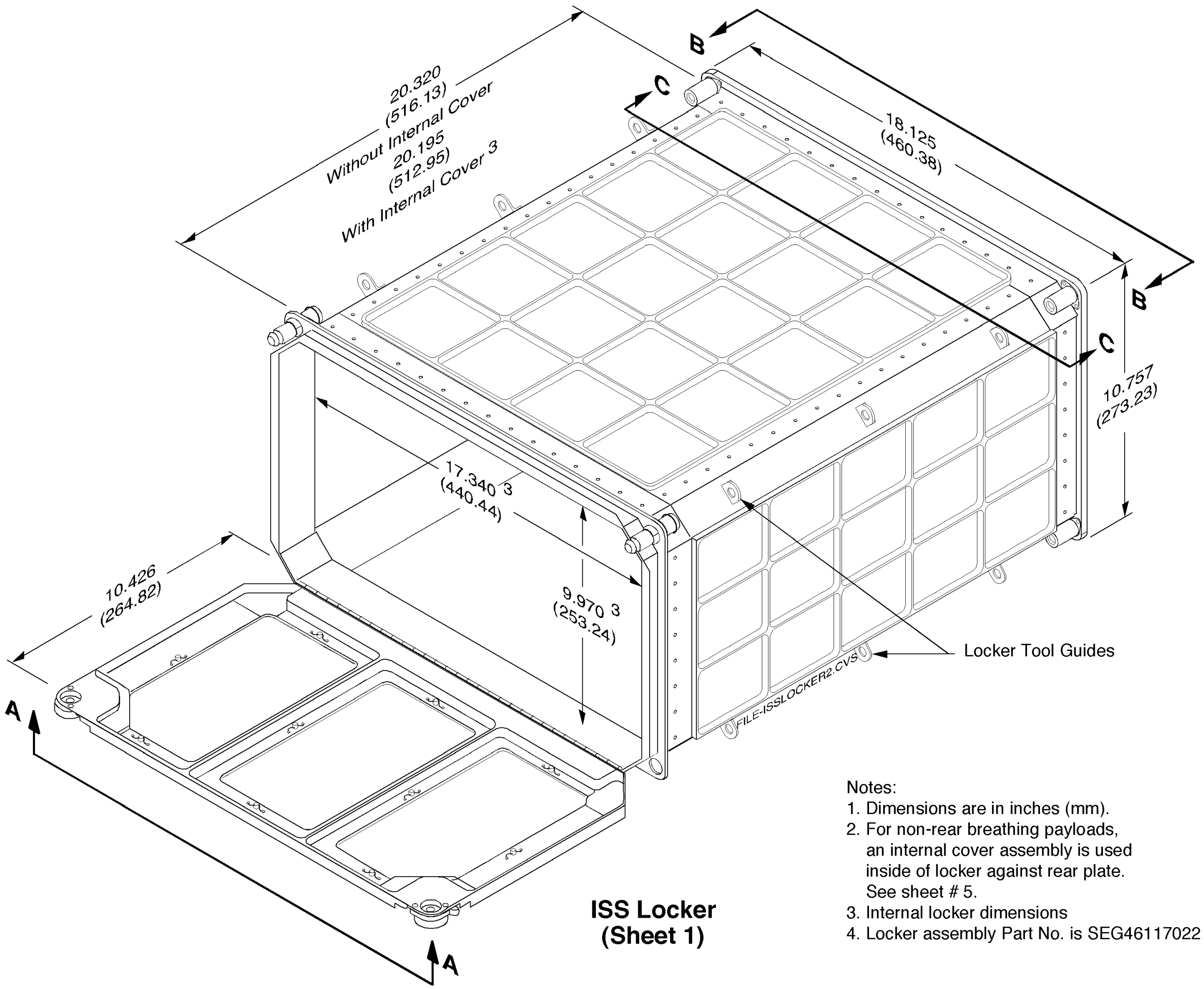
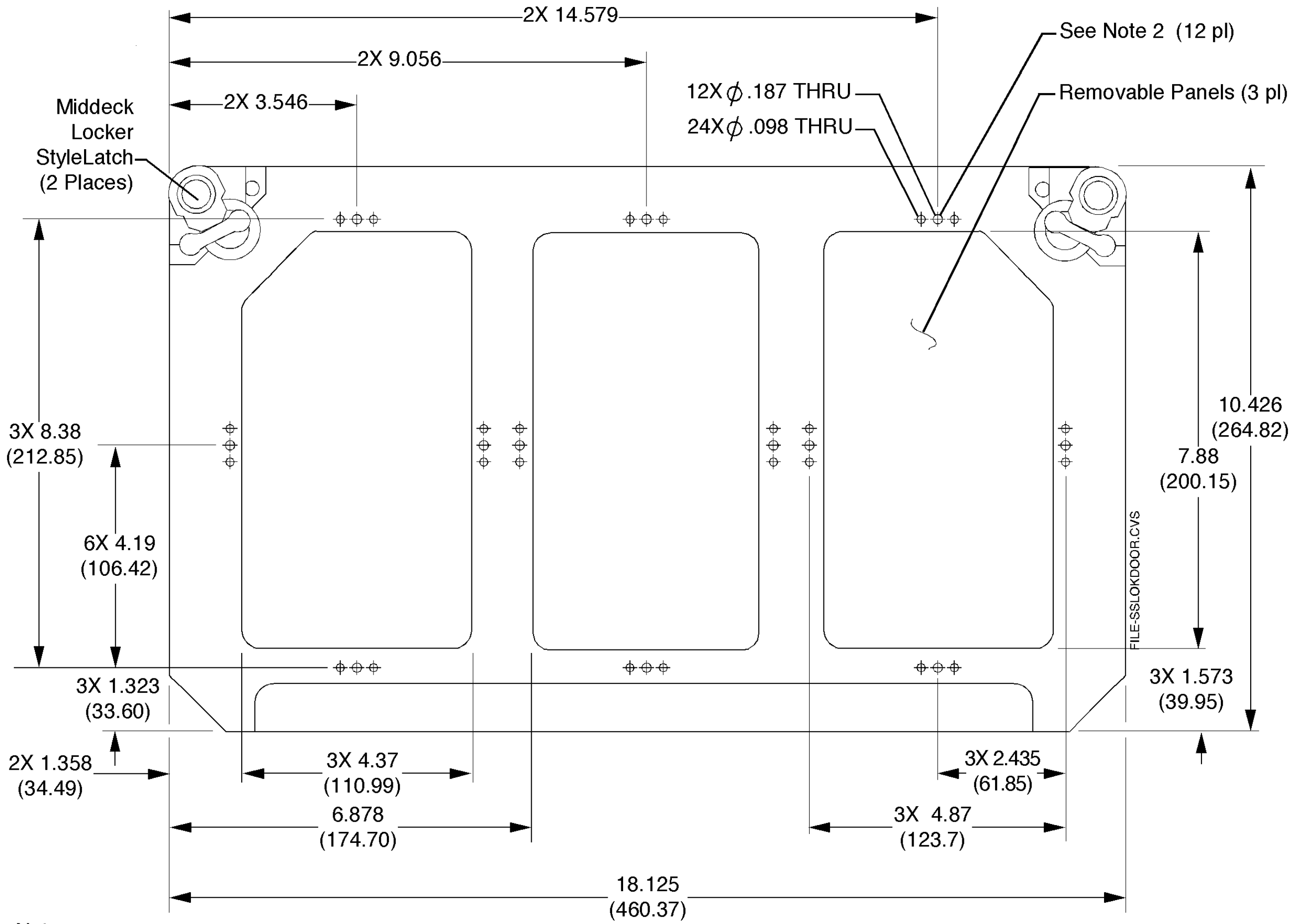


FIGURE 3-8A ISS LOCKER (Sheet 1 of 5)

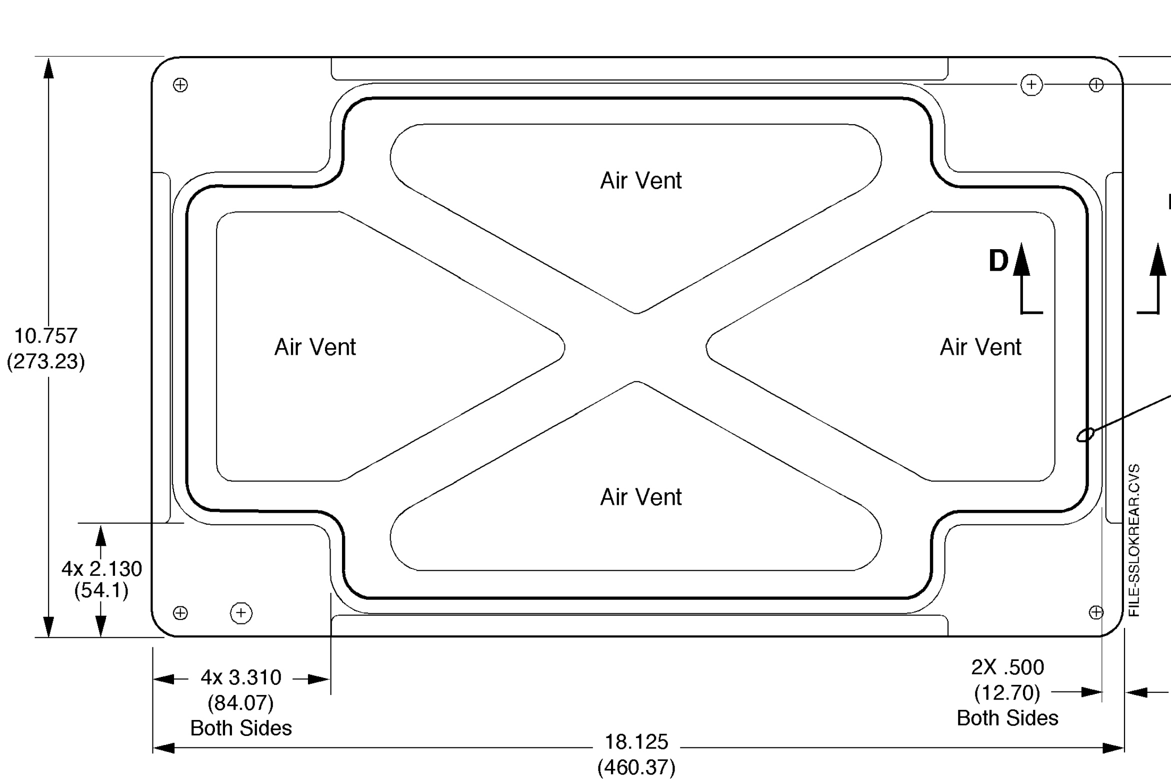


Notes:
1. Dimensions are in inches (mm).
2. Panels interface to door using the following hardware:
   a. 1/4 Turn DZUS Stud, P/N APRJ30SS.
   b. Retainer, P/N SR3SS
   c. Quantities 4 per panel

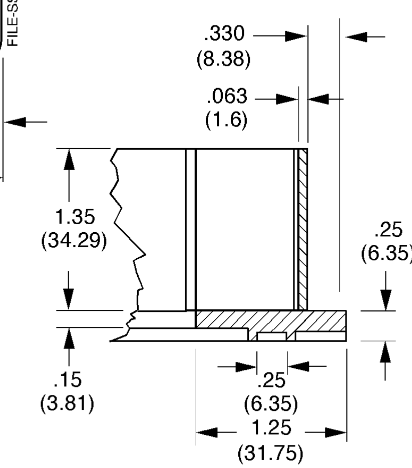
FRONT VIEW (A-A)

ISS Locker Door
(Sheet 2)

FIGURE 3-8A ISS LOCKER DOOR (Sheet 2 of 5)



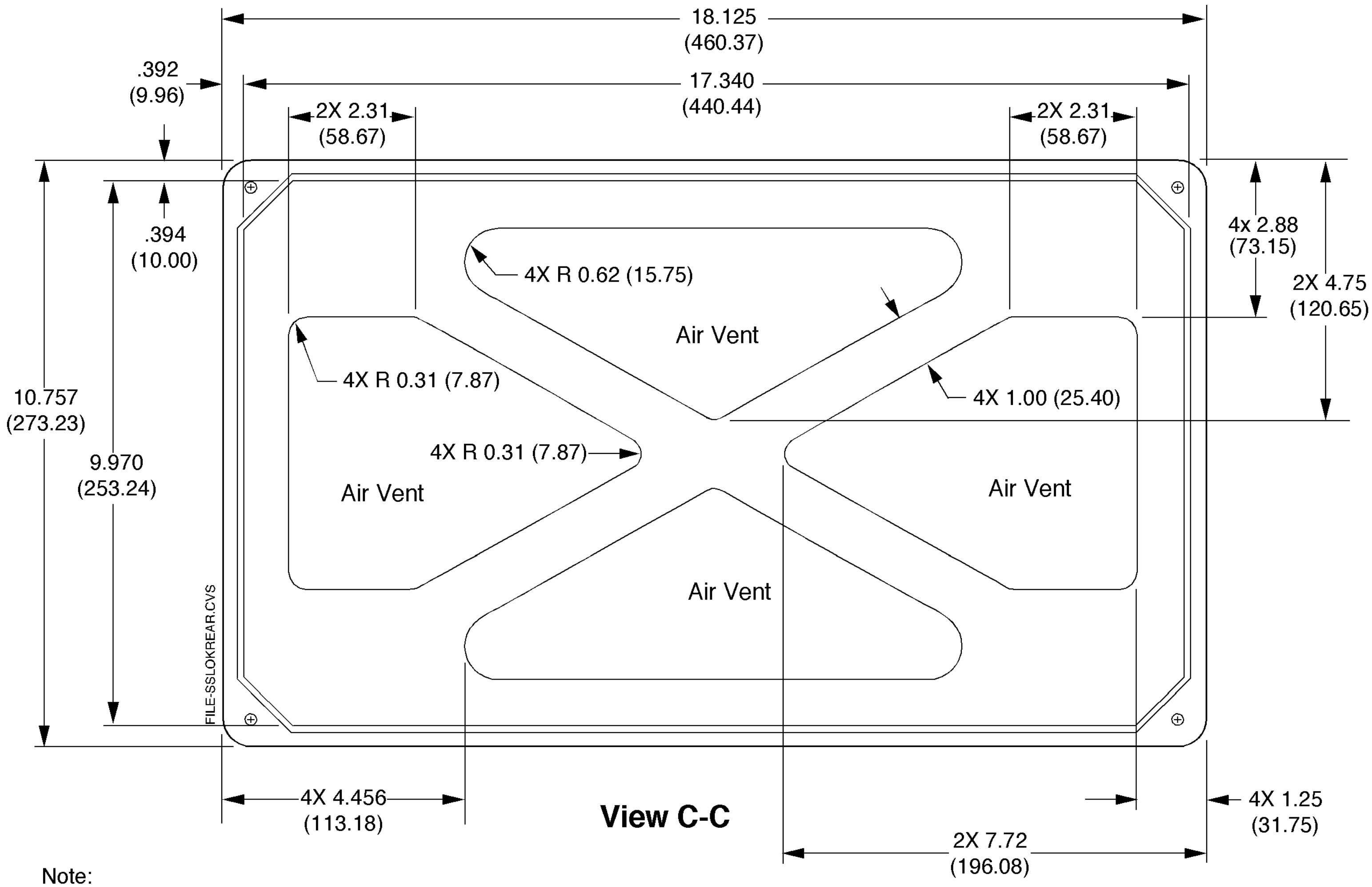
View B-B
ISS Single Locker Rear Plate Assembly
(Sheet 3)



Section D-D

Notes:
1. Dimensions are in inches (mm).
2. Seal is Silicone Sponge Rubber per AMS 3195, P/N R10460 0.25 in x 0.12 in.
3. See View D-D for seal Description.
4. View shown for reference only since it shows the ISS Locker to EXPRESS Rack or SSP Wire Tray mounting interfaces.

FIGURE 3-8A ISS SINGLE LOCKER REAR PLATE ASSEMBLY (Sheet 3 of 5)



Note:
1. Dimensions are in inches (mm).

ISS Single Locker Rear Plate Assembly (Sheet 4)

FIGURE 3-8A ISS SINGLE LOCKER REAR PLATE ASSEMBLY (Sheet 4 of 5)

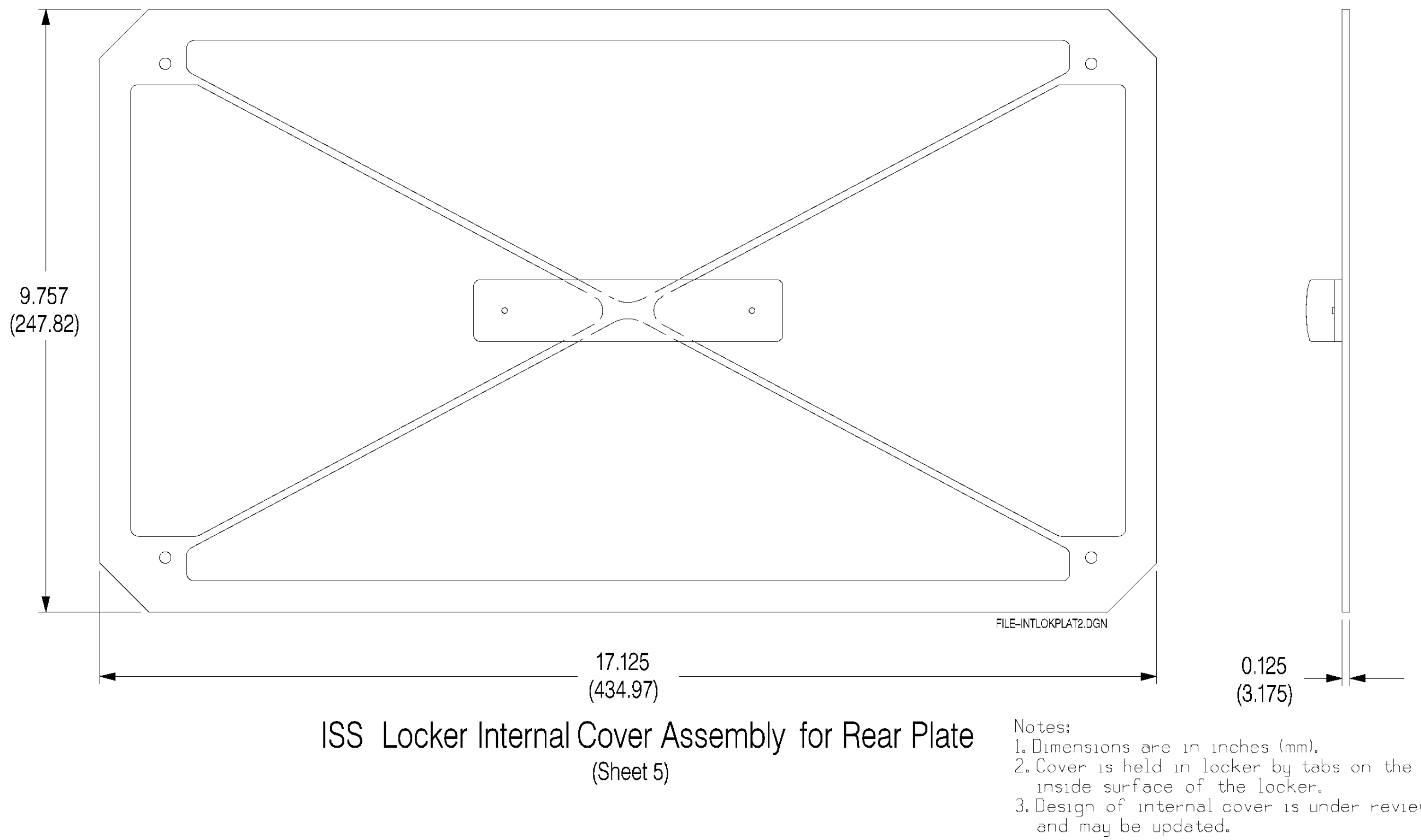


FIGURE 3-8A ISS LOCKER INTERNAL COVER ASSEMBLY FOR REAR PLATE (Sheet 5 of 5)

3.4.2.6 PD-Supplied Locker Requirements

In order to maintain commonality and standardization between Space Shuttle Program-supplied, SpaceHab-supplied, and ISS-supplied and unique PD-supplied lockers, the lockers must meet the requirements within this IDD.

A. All PD-supplied lockers shall use the latches defined by the following drawings:

Knob (Dwg. No. SDD39119020)

Stud (Dwg. No. SDD39119023)

Base (Dwg. No. SDD39119021)

Latch Handle (Dwg. No. SDD39119025)

These parts are made of CRES 15-5 PH (H1025).

B. The following summary of applicable requirements in this IDD is:

(1) Structural strength must be per paragraphs 4.1, 4.2, 4.3, 4.4, 4.5, and 4.6 of this document and SSP 52005.

(2) Structural stiffness and frequency must be per paragraphs 4.1, 4.1.1, 4.2, 4.3, 4.4, and 4.5 of this document and SSP 52005.

(3) Material selection and processing must be per paragraph 13.1 of this document.

(4) Structural/mechanical interfaces must be per paragraph 3.4 of this document. Note: Attachment directly to the middeck wire tray is not allowed.

(5) Size and volume constraints (internal/external) must be per paragraph 3.6 of this document.

(6) Weight and CG constraints must be per paragraph 4.4 of this document.

(7) Containment of stowed mass inside the locker must be per paragraph 3.4.2.3 and SSP 52005.

(8) Special manufacturing and/or assembly operations must be per paragraph 13.1 of this document.

(9) On-orbit removability/reconfigurability/interchangeability must be per the combined requirements of Section 3 of this document.

(10) Pressurization/depressurization must be per paragraph 4.8 of this document.

Note: The verification of the above requirements is defined in the Payload Verification Plan Blank Book, SSP 52000-PVP-ERP.

3.4.3 Mounting Panels

Payloads heavier or of a larger size than those that can be accommodated by a standard stowage locker may be mounted via PMPs, single adapter plates, double adapter plates, or VPMPs. Payload baseplate thickness shall be 0.25 (tolerances are per Section 3.2). If panels are used in the middeck, these panels or item of equivalent stiffness will remain installed for middeck strength considerations. Reference Figure 3-2 for coordinate system references.

3.4.3.1 Single Adapter Plate

Payloads requiring an adapter plate interface may be attached directly to a single adapter plate using a universal hole pattern for attachment. Maximum payload envelope and attaching hole pattern are defined in Figure 3-9. Payloads shall not protrude more than 20.312 in along the XPL axis from the face of the adapter plate. This applies to mounting either in the orbiter middeck or in the EXPRESS Rack. Single adapter plate weight is 6.2 lb, and its thickness is 0.750 in.

3.4.3.2 Double Adapter Plate

Payloads which are heavier or of a larger size than those than can be accommodated inside a standard stowage locker or attached to a single adapter plate or a PMP may be attached to a double adapter plate. The double adapter plate has a universal hole pattern for payload attachment. Maximum payload envelope and attaching hole pattern are defined in Figure 3-10. Double adapter plate weight is 15.0 lb, and its thickness is .875 in.

Double adapter plates attach to two single adapter plates or to two PMPs installed one above the other to the avionics bay structure interface in the orbiter middeck as shown in Figure 3-11. If the double adapter plate is mounted to two single adapter plates, the payload shall not protrude more than 19.437 in along the X_{PL} axis from the face of the double adapter plate. This applies to mounting either in the Shuttle middeck or in the EXPRESS Rack. If the double adapter plate is mounted to two PMPs, the payload shall not protrude more than 19.687 in along the X_{PL} axis from the face of the double adapter plate. This applies to mounting either in the Shuttle middeck or in the EXPRESS Rack.

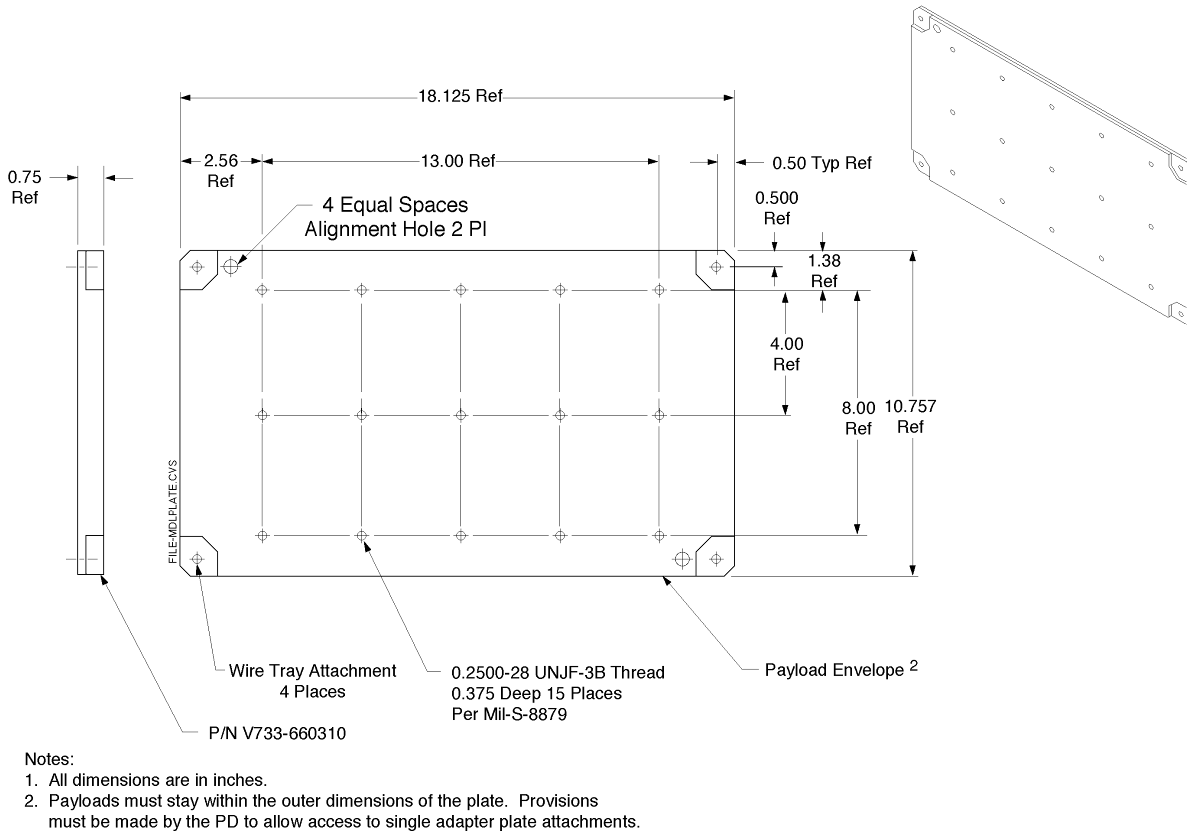


FIGURE 3-9 SINGLE ADAPTER PLATE (CONTROLLED IN THE MIDDECK IDD)

3.4.3.3 Payload Mounting Panel

Payloads requiring panel interface may be attached directly to a PMP or directly to two PMPs thus eliminating the need for a double adapter plate. The hole patterns and mounting methods are defined in Figure 3-12. Payloads shall not protrude more than 20.562 in along the XPL axis from the face of the mounting panel. This applies to mounting either in the Shuttle middeck or in the EXPRESS Rack. A single PMP weight is 3.5 lb with a thickness of 0.500 in.

3.4.3.4 Vented Payload Mounting Panel

Actively cooled (i.e., ducted air) payloads may be mounted to VPMPs to accommodate orbiter-ducted air cooling interfaces. Actively cooled (ducted air) single

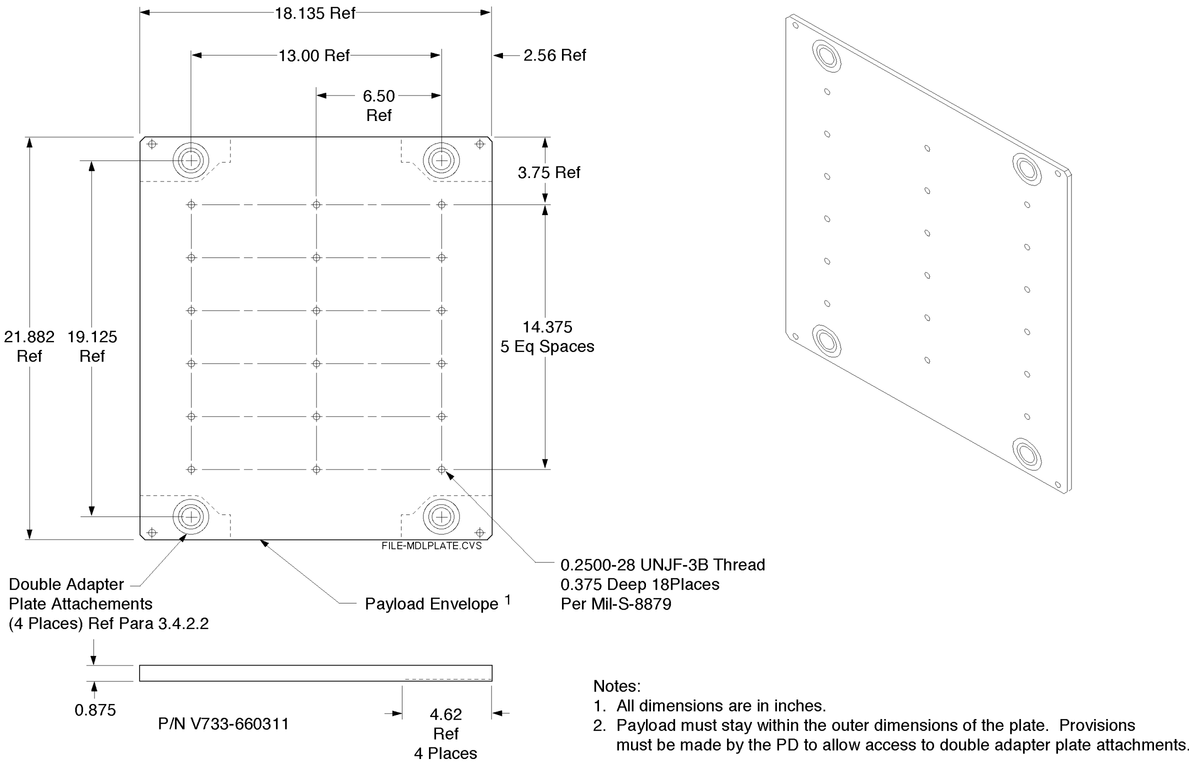


FIGURE 3-10 DOUBLE ADAPTER PLATE (CONTROLLED IN THE MIDDECK IDD)

payloads may be attached directly to a VPMP. Non-active (i.e., non-ducted) single or double payloads may be mounted to VPMPs in lieu of single adapter plates or PMPs. Double payloads will require use of two VPMPs. Because of misalignments from one wire tray to the next, the backplate of the double payload shall incorporate eccentric bushings configured identical to the double adapter plate (reference Figures 3-10 and 3-11). Payload baseplate mounting hole patterns and mounting methods shall be as defined in Figures 3-13 and 3-14. Payloads shall not protrude more than 20.562 inches along the X_{pl} axis from the face of the mounting panel at the payload interface. This applies to mounting either in the Shuttle middeck or in the EXPRESS Rack. A single VPMP weight is 3.5 +0/-1.0 lb with a thickness of 0.500 inches.

3.4.3.4.1 Orbiter Inlet/Outlet Locations for Ducted Air-Cooled Payloads

A single outlet duct will be allocated for either a single- or double-size payload. Ducted cooling configurations will be limited to four allowable configurations, one for single and three for double, as identified in the following paragraphs.

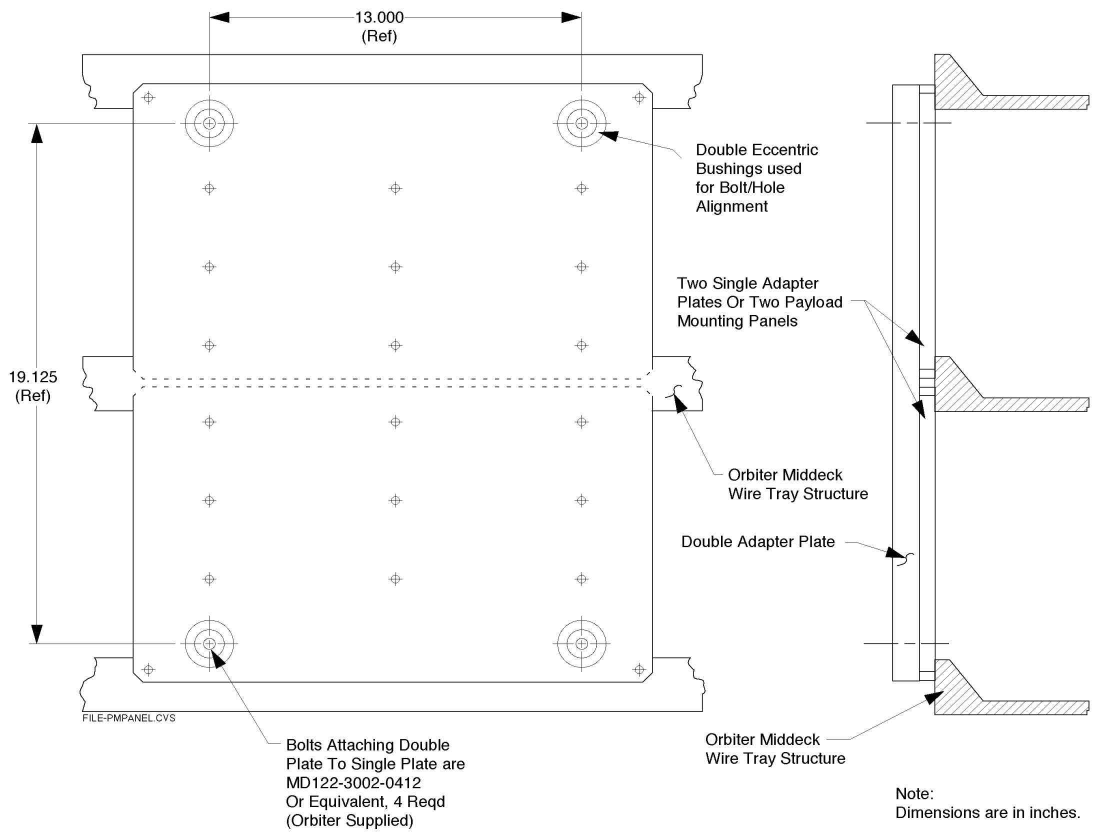


FIGURE 3-11 DOUBLE ADAPTER PLATE (WITH PMPs OR SINGLE ADAPTER PLATE (SAP) ATTACHMENT TO ORBITER MIDDECK WIRE TRAYS OR EXPRESS RACK BACK-PLATE (CONTROLLED IN THE MIDDECK IDD))

Payloads shall locate outlets on either side of the VPMP crossmember or shall provide fan performance that would overcome the obstruction if outlets are located directly over the crossmember. Payloads shall locate their inlets and outlets on opposite halves of the payload.

3.4.3.4.1.1 Orbiter Inlet/Outlet Locations for Single Payload Accommodations

The orbiter inlet is the payload air inlet (cold avionics bay air), and the orbiter outlet is the payload air outlet (hot payload air). The inlet and outlet locations for single payload accommodations will be as shown in Figure 3-13, and payloads using avionics bay air shall be compatible with this figure.

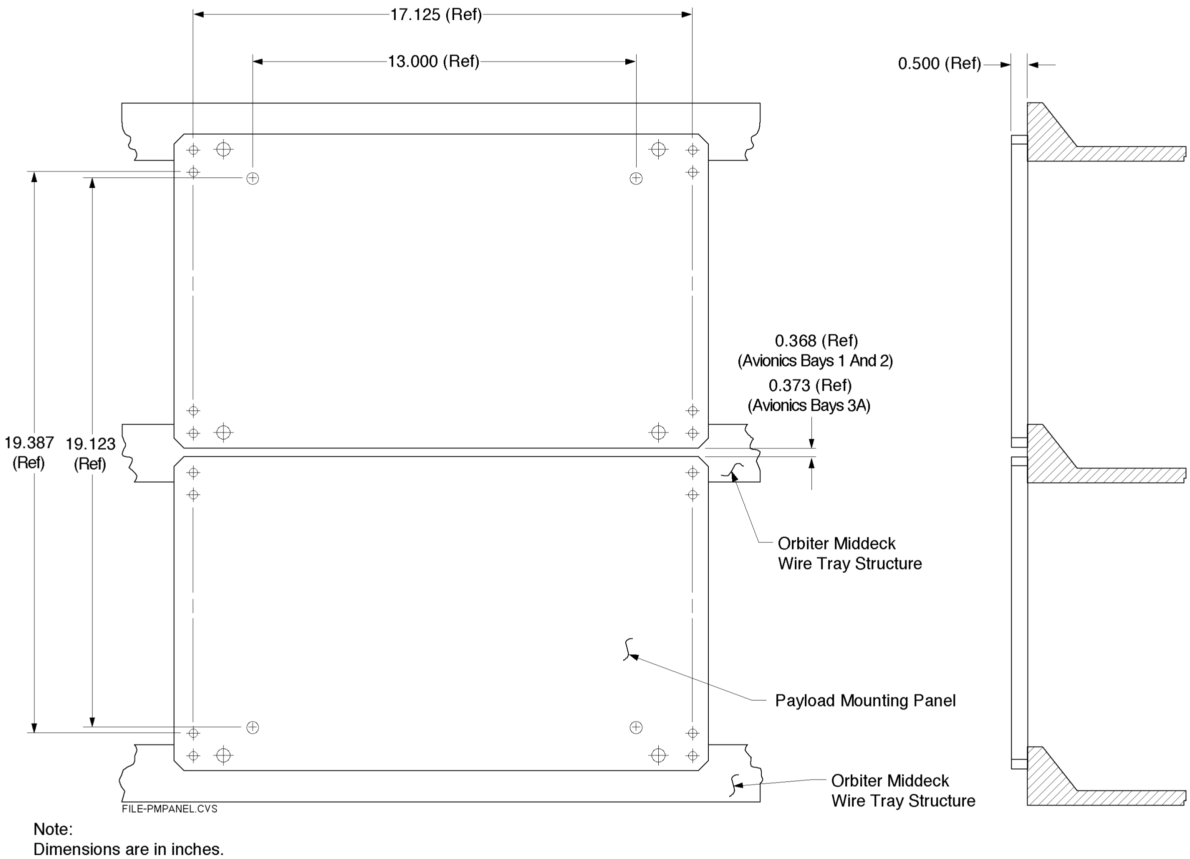


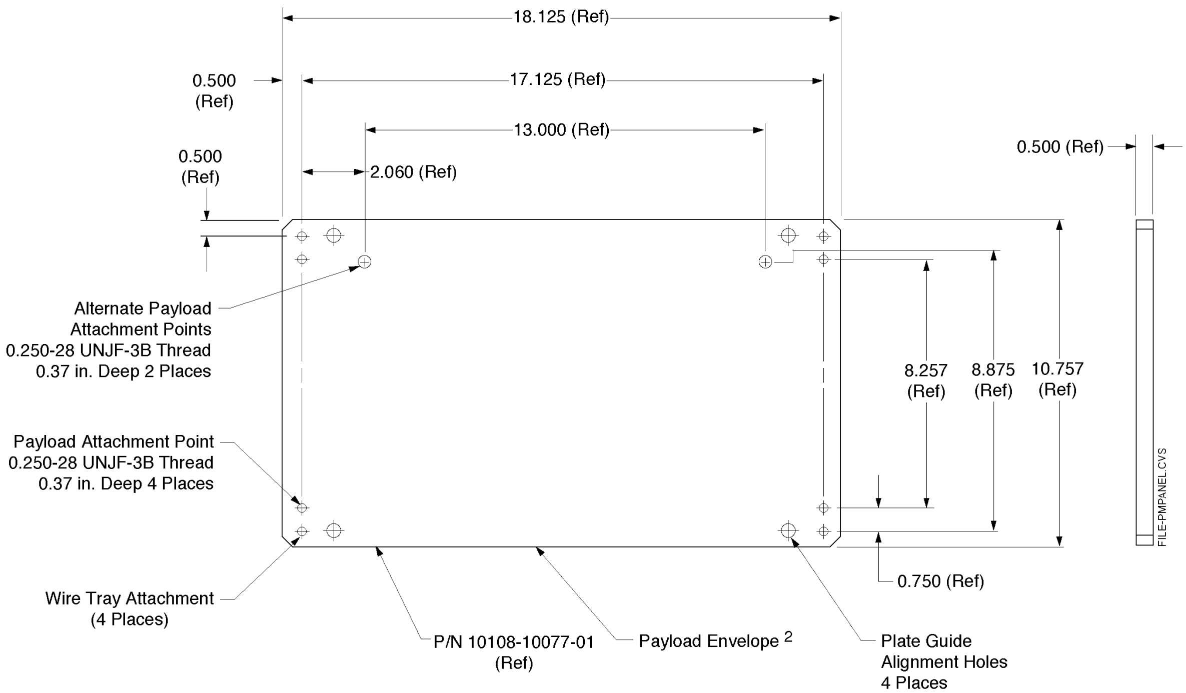
FIGURE 3-12 PAYLOAD MOUNTING PANEL (CONTROLLED IN THE MIDDECK IDD) (Sheet 1 of 2)

3.4.3.4.1.2 Orbiter Inlet/Outlet Locations for Double Payload Accommodations

The orbiter inlet and outlet locations for double payload accommodations will be as shown in Figure 3-14, and payloads using avionics bay air shall be compatible with this figure. Specific orbiter configurations of inlets and outlets will be based upon double payload flow rate needs as defined in paragraph 5.3.1.4.

For double-size payloads with their air inlets and outlets on the top half of the payload, the air cooling interface will be as shown in Figure 3-14 (Sheet 1 of 3). This configuration does not require a payload-provided minimum gap.

For double-size payloads with inlet on bottom half and outlet on top half of payload, the air cooling interface will be as shown in Figure 3-14 (Sheet 2 of 3).



Notes:
1. All dimensions are in inches.
2. Payloads must stay within the outer dimensions of the plate. Provisions must be made by the PD to allow access to adapter plate (corner mounting wire tray) attachments.

FIGURE 3-12 PAYLOAD MOUNTING PANEL (CONTROLLED IN THE MIDDECK IDD) (Sheet 2 of 2)

Sheet 2 of 3 configuration can be used if there is a minimum of 0.75 in gap between the VPMP panel and the payload to allow air recirculation from the plenum to air inlet. This gap may be part of the payload design.

Sheet 3 of 3 shall be used if there is no payload-provided minimum 0.75 in gap.

3.4.3.5 Mounting Access

When payloads are attached to PMPs, single adapter plates, double adapter plates, or VPMPs, clearance shall be provided for the tool to engage the payload mounting bolts from the cabin. Minimum clearance required must be per paragraph 12.12.2.

3.4.3.5.1 On-Orbit Separation Interface Requirements

A. On-orbit separation interface shall be between the payloads and the single or double adapter plates, PMP, or VPMP.

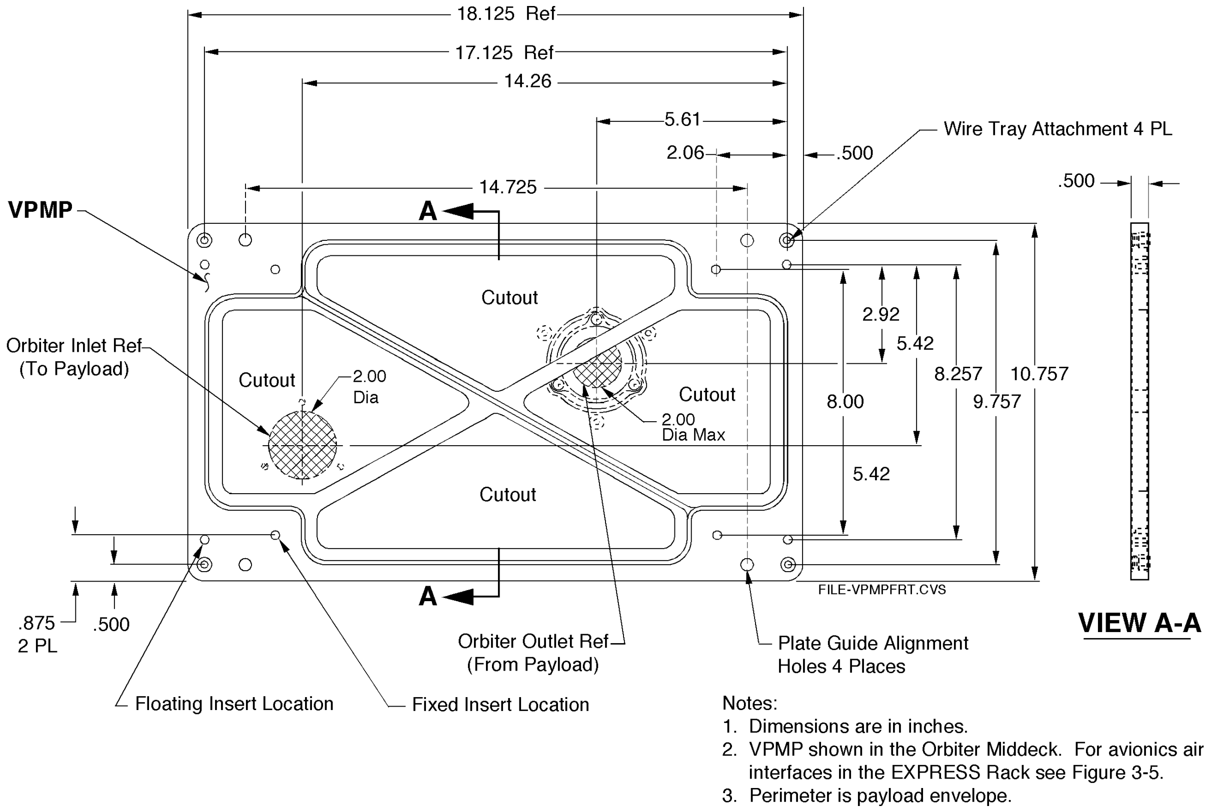


FIGURE 3-13 SINGLE PAYLOAD INLET/OUTLET INTERFACE PROVISIONS (CONTROLLED IN THE MIDDECK IDD) (Sheet 1 of 2)

B. Payloads shall be designed to allow access to the payload mounting bolts as defined in paragraphs 3.4.3.6 through 3.4.3.6.3.

C. Payload equipment shall not require the use of special tools for payload removal unless the tool is supplied by the PD. PDs are encouraged to use standard metric/English fasteners and tools.

3.4.3.5.2 Closeout Cover Access

Payloads utilizing active air cooling or those payloads not requiring active air cooling with the orbiter shall be designed to allow VPMP closeout cover installation/removal. This closeout cover will cover the open forced air cooling interface and will be orbiter provided. This requirement will necessitate the payload-to-VPMP interface to be clear of any obstacles which would preclude placing the cover on the VPMP.

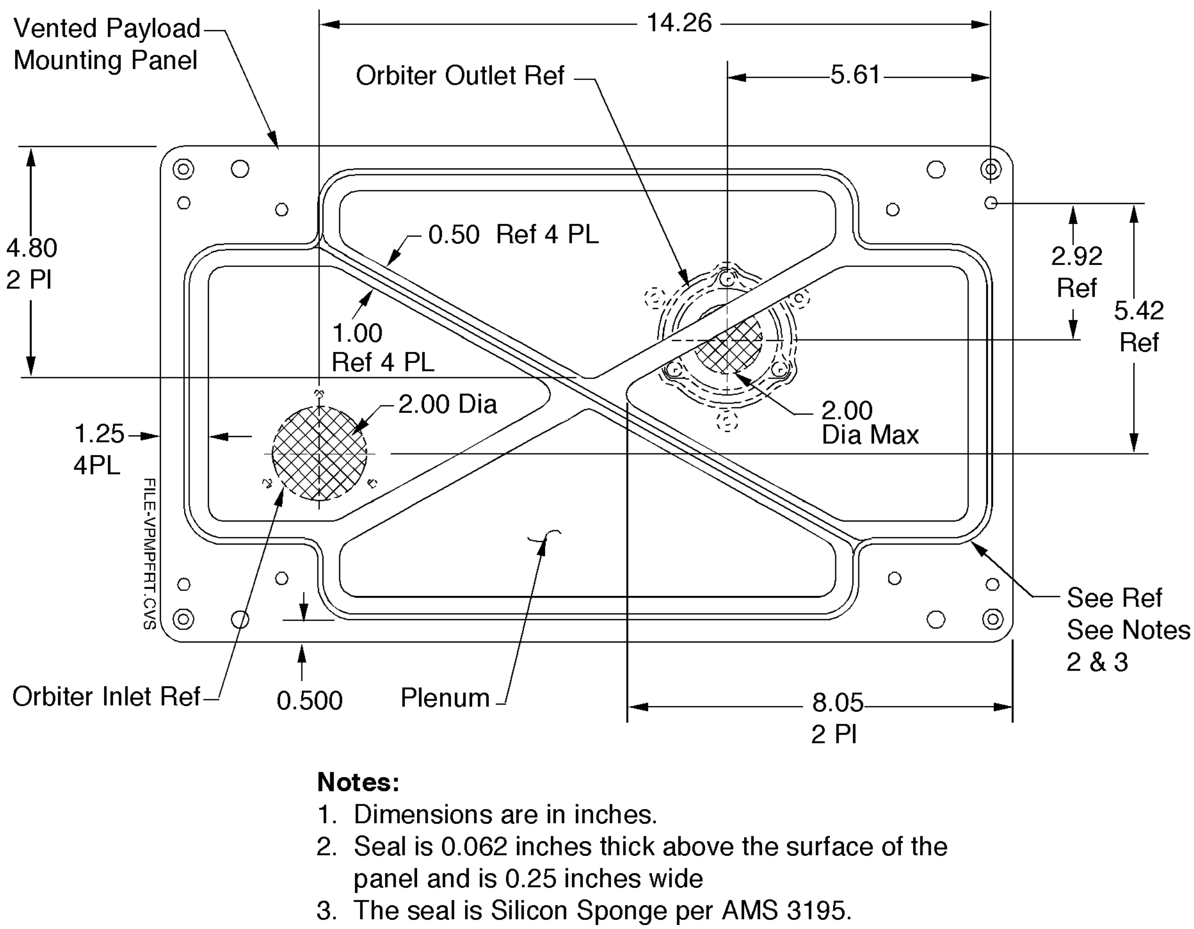


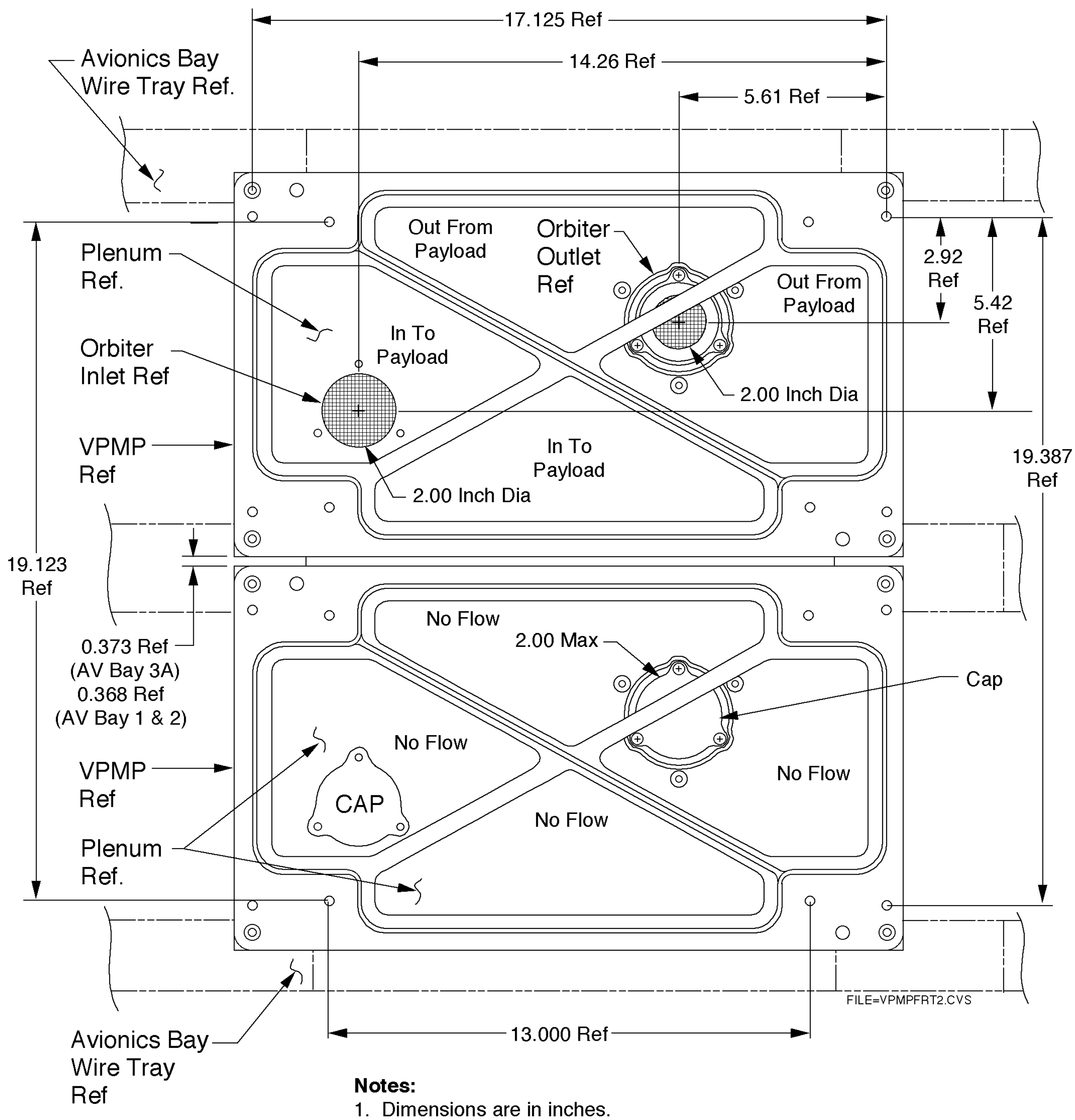
FIGURE 3-13 SINGLE PAYLOAD INLET/OUTLET INTERFACE PROVISIONS (CONTROLLED IN THE MIDDECK IDD) (Sheet 2 of 2)

3.4.3.6 Payload Attachment Point Provisions

3.4.3.6.1 Orbiter/Middeck

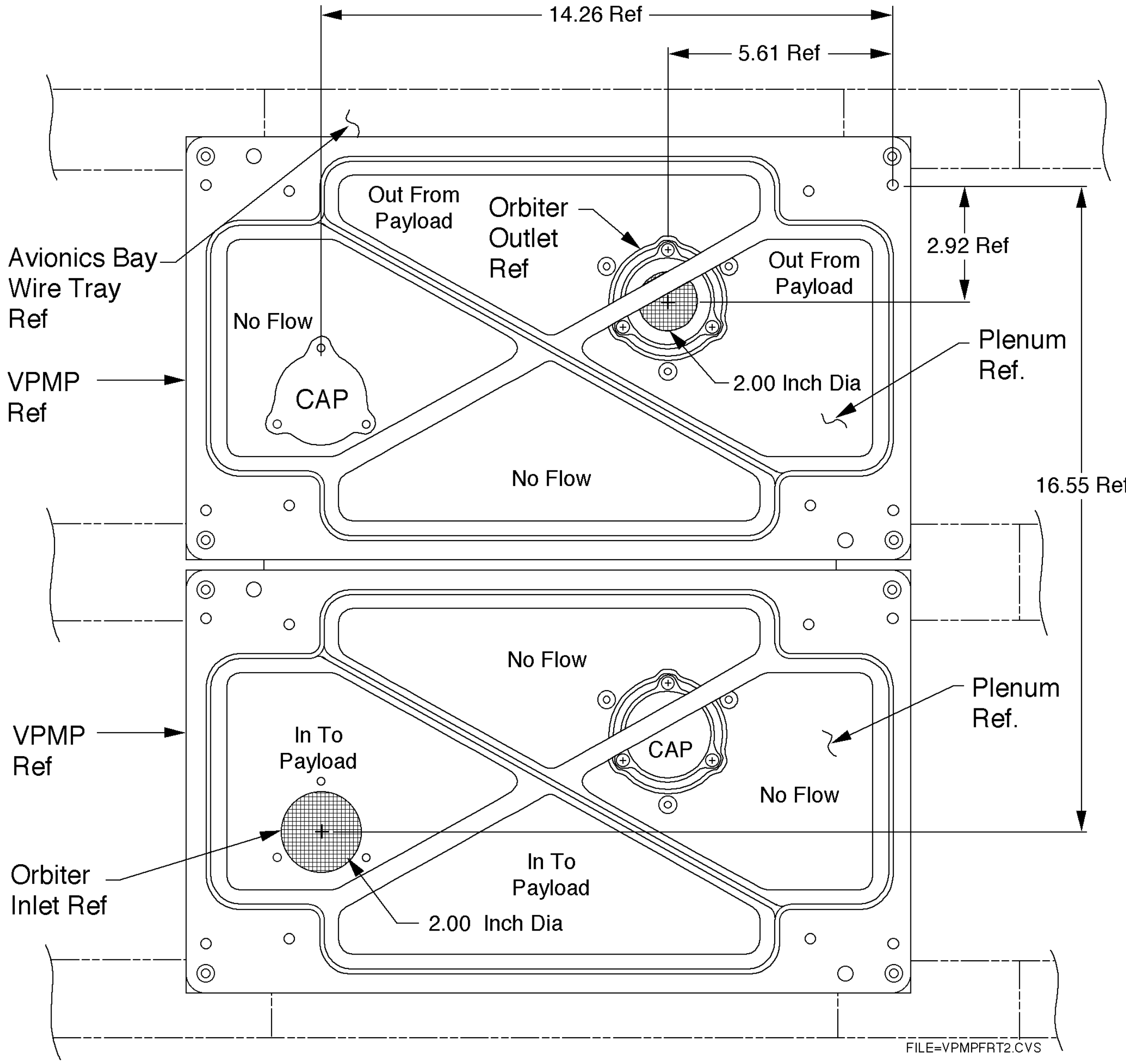
3.4.3.6.1.1 Attachment Hardware – Payloads without Planned On-Orbit Transfers

For payloads without planned on-orbit transfers, the attachment points on the payload for securing to an adapter plate, payload mounting panel, or vented payload mounting panel shall be designed per Figure 3-15. This requirement will allow the use of SSP-supplied corrosion resistant bolts (NAS-1954C) for flight installation. The mounting bolt holes of the payload must be 0.312 in diameter to provide bolt installation clearance.



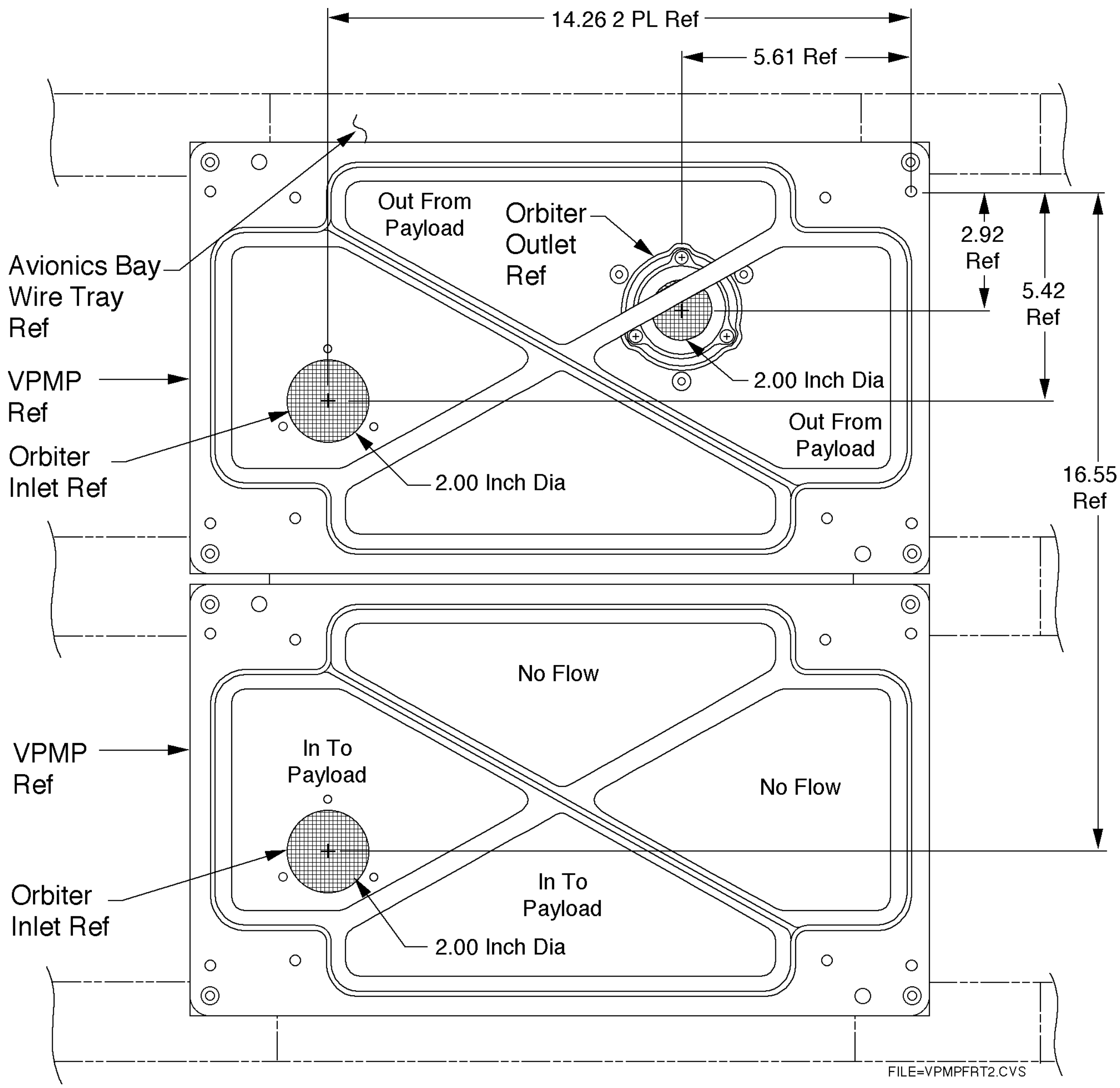
Notes:
1. Dimensions are in inches.
2. VPMP shown in the Orbiter Middeck. For avionics air interfaces in the EXPRESS Rack see Figure 3-5.
3. VPMP thickness is 0.500 inches.

FIGURE 3-14 DOUBLE SIZE PAYLOAD AIR FLOW FUNCTIONAL INTERFACE - TOP PAYLOAD INLET AND OUTLETS (CONTROLLED IN THE MIDDECK IDD) (Sheet 1 of 3)



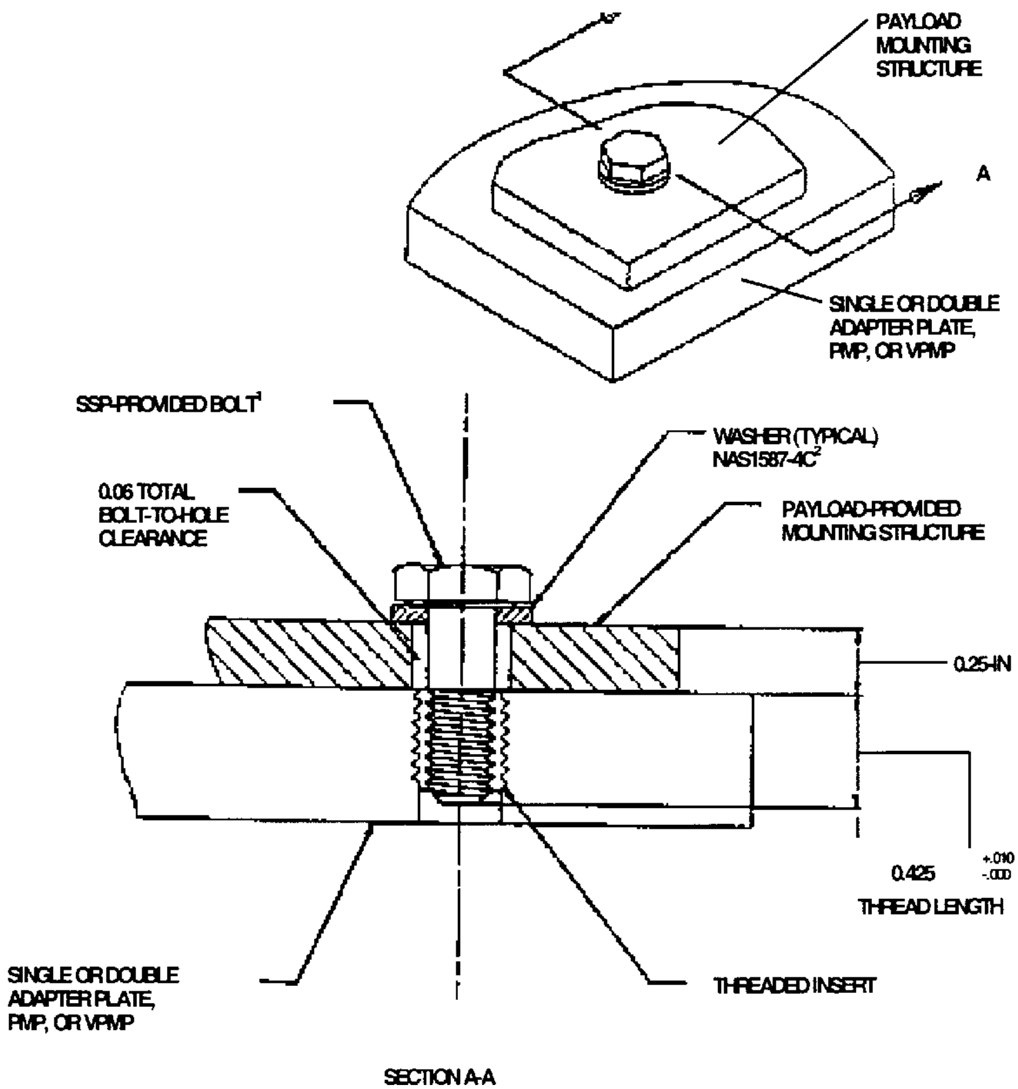
Notes:
1. Dimensions are in inches.
2. VPMP shown in the Orbiter Middeck. For avionics air interfaces in the EXPRESS Rack see Figure 3-5.

FIGURE 3-14 DOUBLE PAYLOAD INLET/OUTLET INTERFACE PROVISIONS - TOP HALF OF OUTLET/BOTTOM HALF OR INLET (MINIMUM 0.75 INCH RECIRCULATION GAP) (CONTROLLED IN THE MIDDECK IDD) (Sheet 2 of 3)



Notes:
1. Dimensions are in inches.
2. VPMP shown in the Orbiter Middeck. For avionics air interfaces in the EXPRESS Rack see Figure 3-5.

FIGURE 3-14 DOUBLE PAYLOAD INLET/OUTLET INTERFACE PROVISIONS - TOP HALF OF OUTLET/BOTTOM HALF OR INLET (NO MINIMUM 0.75 INCH RECIRCULATION GAP) (CONTROLLED IN THE MIDDECK IDD) (Sheet 3 of 3)



NOTES:

1. Payloads which attach directly to the Orbiter middeck wire trays and are not planned to be removed on-orbit will use Orbiter-provided attachment hardware (NAS1954C).
2. Anti-seize agent used per payload requirements
3. Dimensions are in inches (mm).
4. Captive feature and locking feature for standard Orbiter fasteners are under development.

FIGURE 3-15 PAYLOAD/STS ATTACHMENT POINT DETAILS FOR NO PLANNED ON-ORBIT TRANSFER

3.4.3.6.1.2 Attachment Hardware – Payloads with Planned On-Orbit Transfers

For payloads with planned on-orbit transfers, the attachment points on the payload for securing to an adapter plate, payload mounting panel, or vented payload mounting panel shall be payload supplied and shall be designed per the requirements in Table 3-I.

TABLE 3-I FASTENER REQUIREMENTS FOR PAYLOADS WITH PLANNED ON-ORBIT TRANSFERS

ITEM	REQUIREMENT
1	Fasteners are required for flight installation
2	Fasteners are payload-supplied
3	Fasteners are compatible with shuttle-provided inserts, part number NAS1394CA4 for PMPs. VPMPs have floating inserts, part number ME 115-0070-1004 and fixed inserts, part number NAS1394CA4 as shown in Figure 3-13 (Sheet 1 of 2)
4	Fasteners are captive
5	Fasteners that are retractable (spring loaded away from the mounting plane) and flush or recessed behind the mounting plate when not engaged
6	Fasteners that are silver plated have a secondary locking feature (Safety wire, cotter pins, or similar method is not allows) per MIL0DTL-18240
7	Fasteners have a maximum penetration into the adapter plate, PMP or VPMP equal to 0.480 inches
8	Fasteners have a minimum diametric float capability of 0.040 inches for single payloads, 0.060 inches for double payloads
9	Fasteners have a 3/16 inch internal hex Allen head screw tool interface
10	Fasteners installation torque to be 50 to 75 inch pounds (Total torque includes running torque)

3.4.3.6.2 EXPRESS Rack Backplate

The attachment points on the payload mounting structure for securing to the EXPRESS Rack backplate shall be designed per Figure 3-16. Note: It is recommended that the (1/4-28) threaded inserts be utilized in lieu of the sleeve bolt receptacle attachment points on the EXPRESS Rack backplate (reference Figure 3-5) when the additional load carrying capability is required.

3.4.3.6.2.1 Interface Attachment Capabilities

The interface ultimate force allowables shown in Table 3-II shall be used in the structural analyses/assessment of the EXPRESS Rack backplate interface.

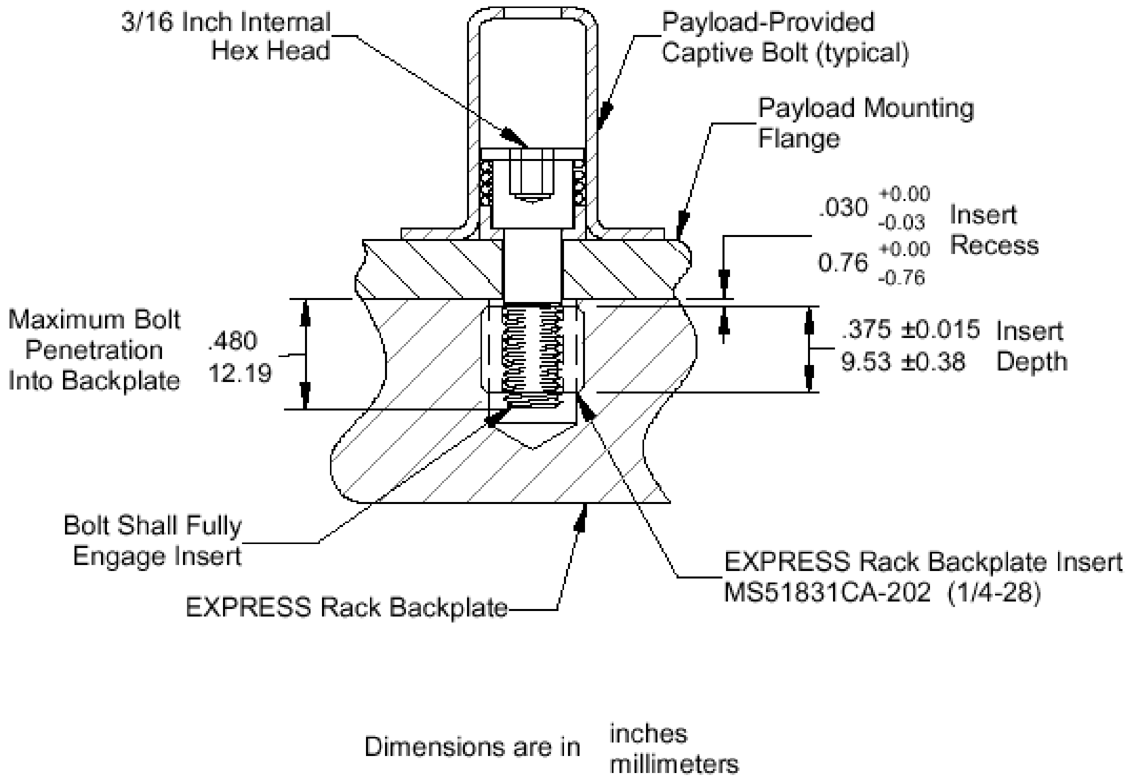


FIGURE 3-16 PAYLOAD/EXPRESS RACK BACKPLATE ATTACHMENT POINT DETAILS (Sheet 1 of 2)

TABLE 3-II ATTACHMENT BOLT RECEPTACLE FORCE ALLOWABLES FOR EXPRESS RACK

	ULTIMATE FORCE ALLOWABLES	
	TENSILE (lbf)	SHEAR (lbf)
Threaded Insert P/N MS51831CA-202	3600	2800
Sleeve Bolt Receptacle P/N SPS 202163-4-2	2500	2800

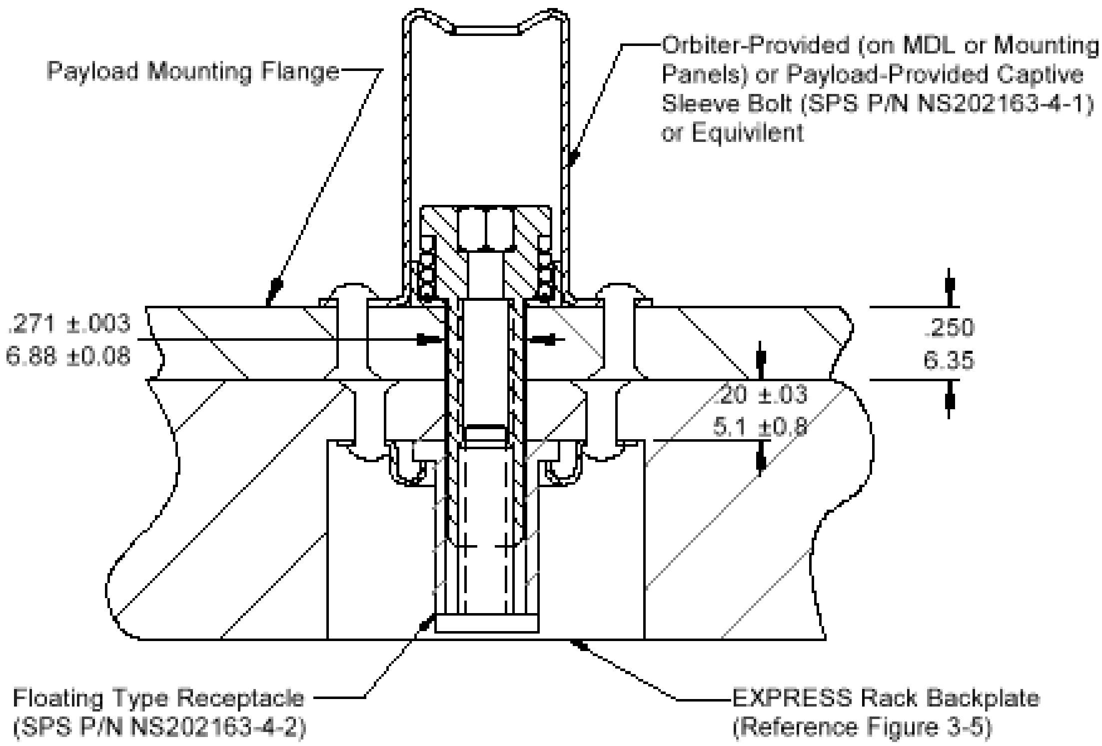


FIGURE 3-16 PAYLOAD/EXPRESS RACK BACKPLATE ATTACHMENT POINT DETAILS (Sheet 2 of 2)

3.4.3.6.2.2 Maximum Dimensions Envelope

The maximum dimension from the backplate surface to the Ground Support Equipment (GSE) boss fittings on the ISPR portion of the EXPRESS Rack is 24.6 in. See Figure 3-17 for illustration. Payloads that are transported only in EXPRESS Racks or transportation racks shall stay within this envelope. PDs are urged to utilize a 24.6 in dimension which does not require a permanent protrusion waiver. Note: The 24.6 in dimension includes all parts of the payload (i.e., connectors, QDs, switches, etc.).

3.4.3.6.3 Captive Fasteners

The payload provides all interface fasteners which attach payload equipment to orbiter-provided mounting plates (single adapter plate, double adapter plate, PMP, VPMP) or to the EXPRESS Rack or EXPRESS Transportation Rack backplates. These interface fasteners shall meet the requirements in Table 3-III and Figure 3-16.

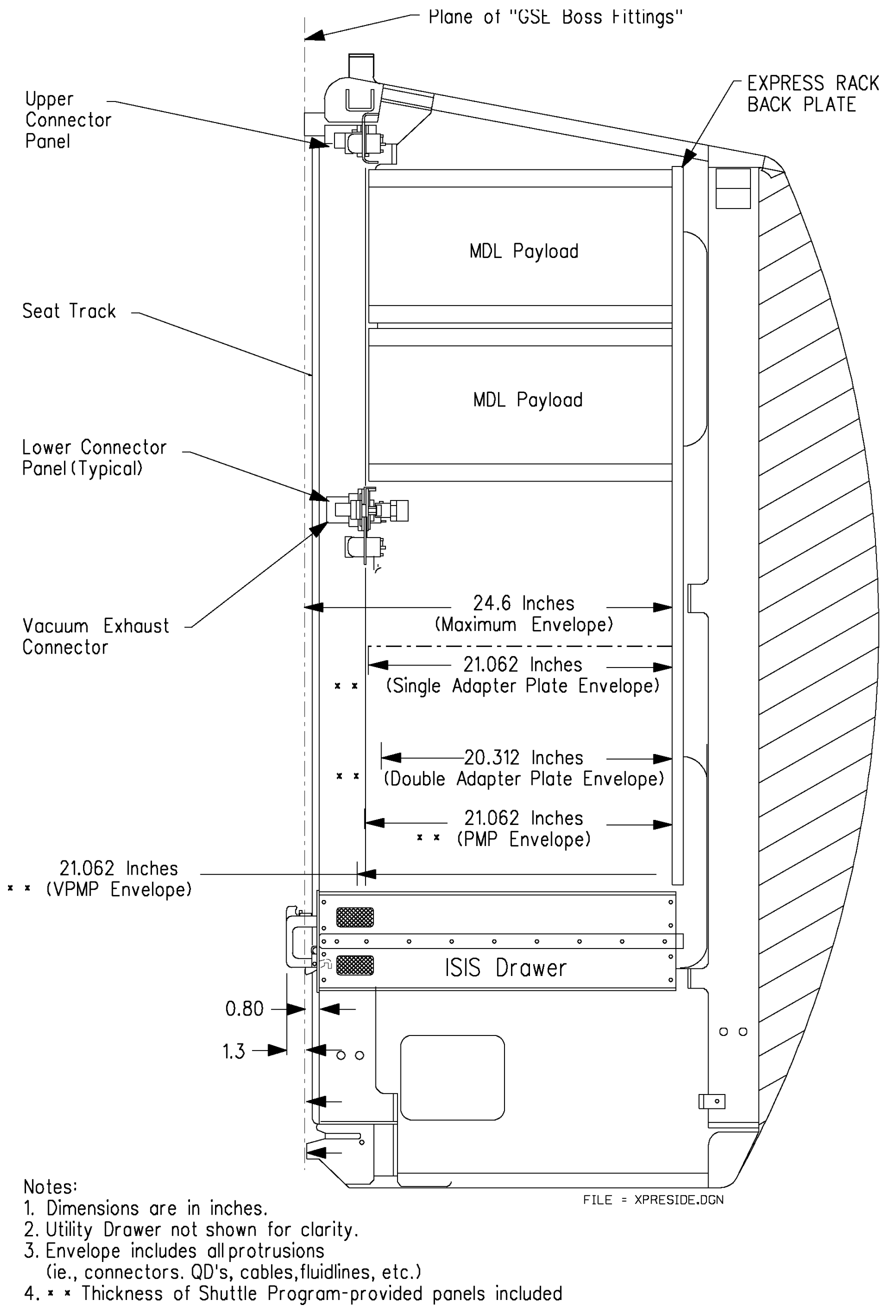


FIGURE 3-17 EXPRESS RACK PAYLOAD ENVELOPES

TABLE 3-III CAPTIVE INTERFACE FASTENER REQUIREMENTS

Held captive to the payload side of the interface
Self locking
Self retracting (spring loaded) at least flush with payload mounting flange
Minimum radial float capability of 0.02 inches for single locker size payloads, 0.03 inches for double and quad locker size payloads
Provision to prevent thread seizing through dry film lubrication, silver plating, or application of approved anti-seize compound
Bolt material A286 CRES, 180 ksi ultimate tensile strength maximum
Ancillary parts (housing, springs, retainer, etc.) made from corrosion resistant steel or aluminum
Compatible with NAS1394CA4 inserts used in the middeck and MS51831CA-202 insert used in the EXPRESS Rack backplate or with NS202163-4-2 sleeve bolt receptacles

NOTE: Modification of non-captive fasteners to incorporate a captive feature must be approved by the structures working group. For all interface bolts to be considered (analytically) to share carrying shear loads to the backplate, the total radial clearance at each bolt must not exceed clearance fit requirements.

3.4.3.6.4 On-Orbit Removal of Fasteners

Safety wires shall not be used on fasteners which must be removed on orbit. Note that fracture-critical fasteners which must be removed on orbit and/or replaced must be safety cabled or cotter pinned.

3.4.4 ISIS Drawer Payload Provisions

Two configurations of ISIS drawers are provided for mounting payloads in the lower portion of the EXPRESS Rack. The stowage ISIS drawer is intended to contain foam-packed passive items which require on-orbit access. The powered ISIS drawer is intended for active items which will remain within the drawer on orbit with no access requirement. The EXPRESS Rack program provides only the 4-PU size ISIS drawer for use in the 8/2 EXPRESS Rack. Internal dimensions of the two drawer designs are shown in Figure 3-18. The PD should identify which type of drawer is required in the payload-unique EIA.

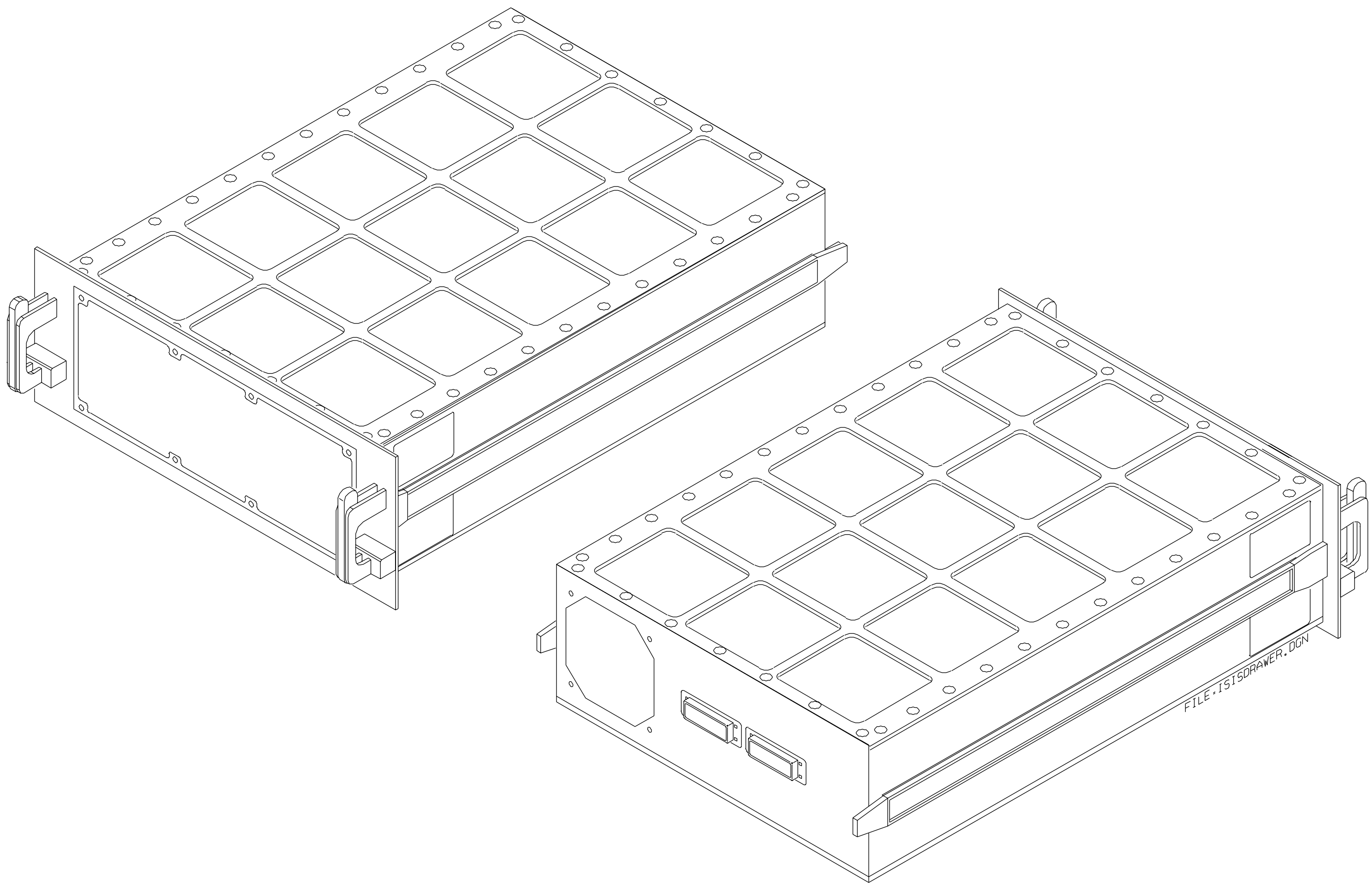


FIGURE 3-18 4-PU ISIS DRAWER DIMENSIONAL LIMITATIONS (Sheet 1 of 3)

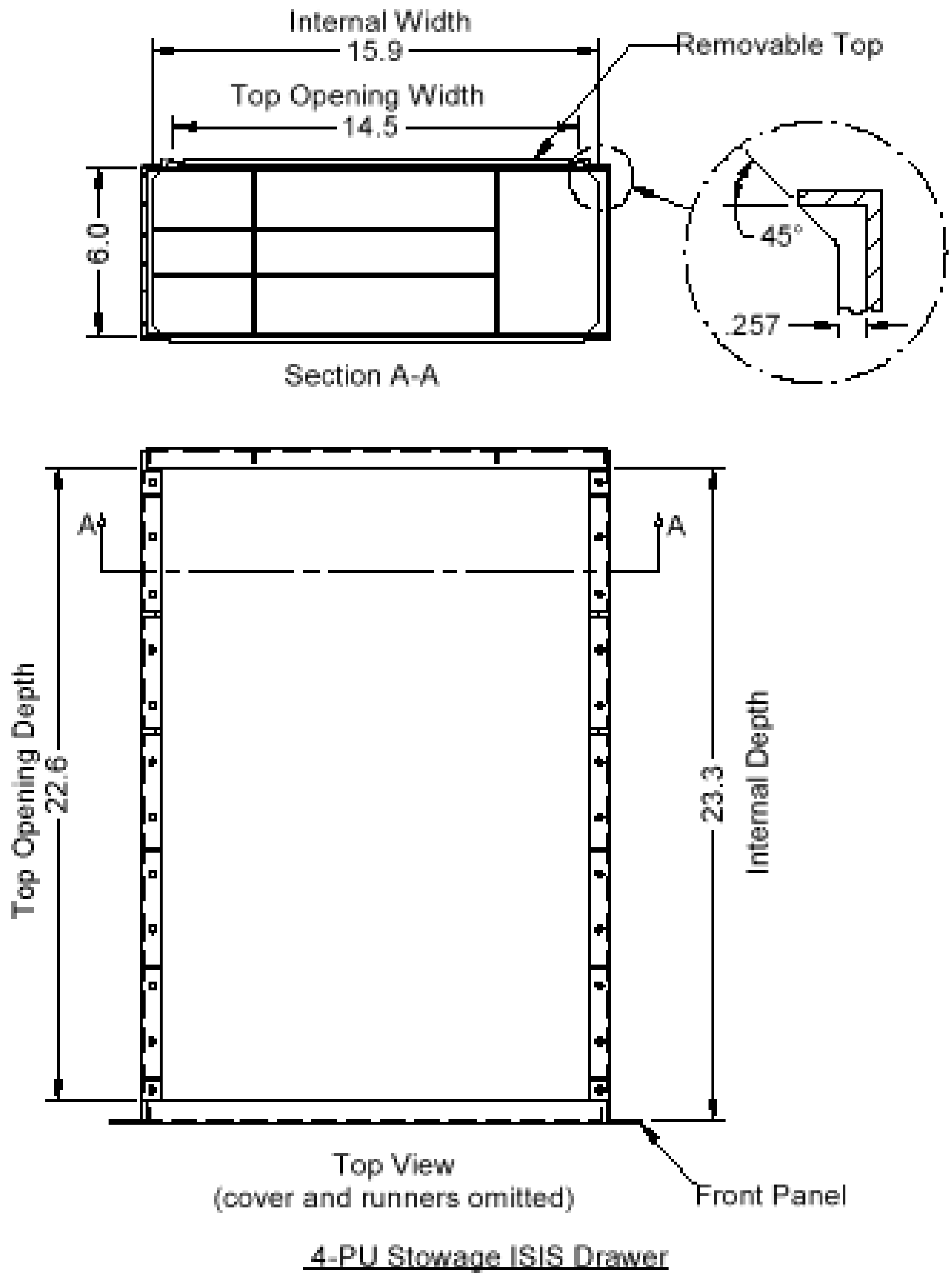


FIGURE 3-18 ISIS DRAWER INTERNAL DIMENSIONS (Sheet 2 of 3)

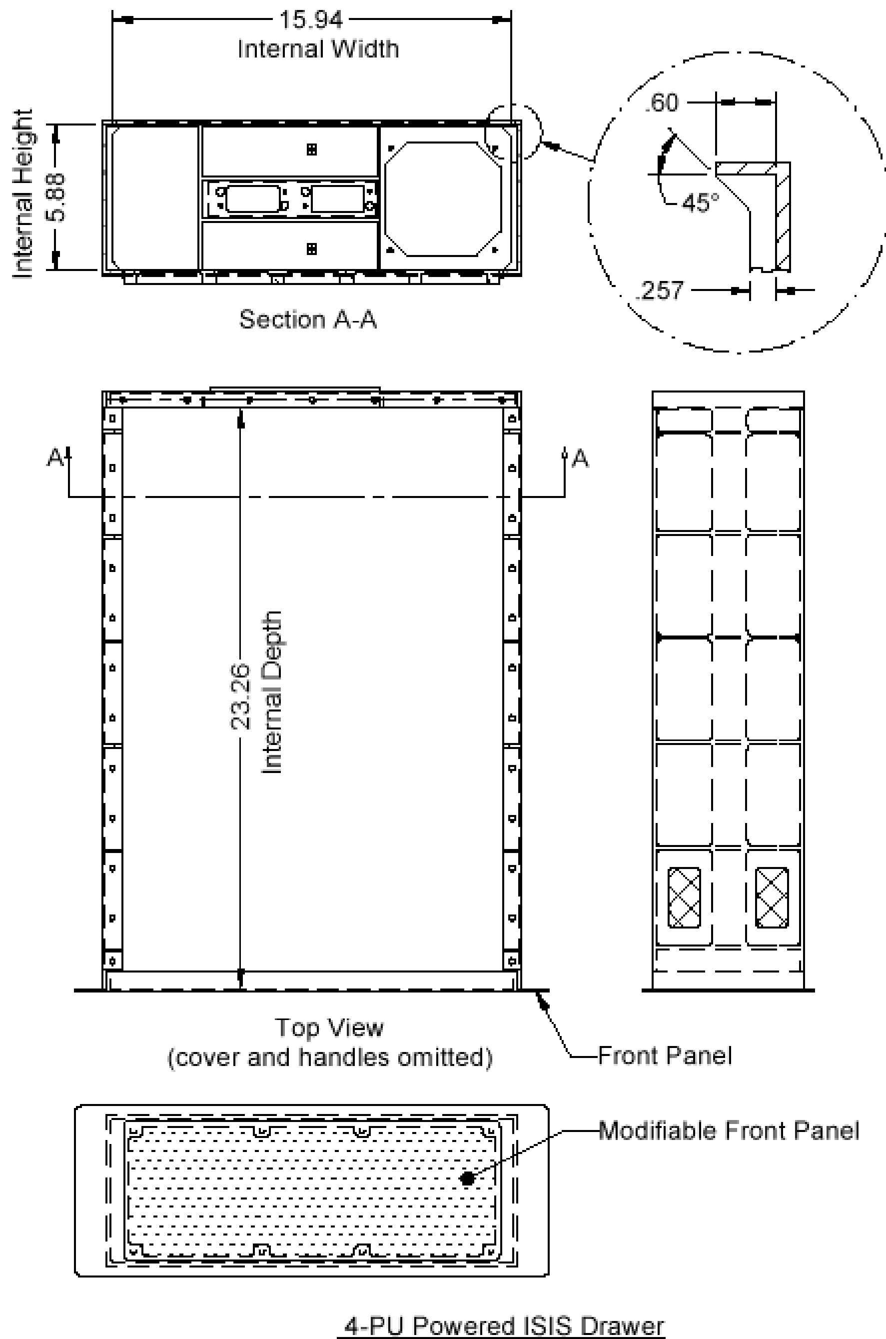


FIGURE 3-18 ISIS DRAWER INTERNAL DIMENSIONS (Sheet 3 of 3)

3.4.4.1 Stowage ISIS Drawers

The stowage ISIS drawer design has a sliding top allowing on-orbit access to stowage payloads. The stowage ISIS drawer has no provision for power or data connections or cooling supply to contained payloads.

PDs are not allowed to modify the stowage ISIS drawer.

The stowage ISIS drawer weighs approximately 20 lb.

A. Payloads located in the stowage ISIS drawers shall be packed in Pyrell foam (or a similar material) with a minimum thickness of 0.5 in.

B. The total mass of payload in a stowage ISIS drawer shall not exceed 44 lb.

C. The total mass and center of gravity of the integrated stowage ISIS drawer shall comply with the limits given in Table 3-IV.

D. Payload stowed in a stowage ISIS drawer shall have a zero-G retention feature to prevent any equipment from floating out of the drawer when the top is open during on-orbit operations.

E. The drawer top shall not be jammed open by the drawer contents.

TABLE 3-IV ISIS DRAWER PAYLOAD MASS AND CENTER OF GRAVITY CONSTRAINTS

DRAWER CONFIGURATION	X (in)	Y (in)	Z (in)
ISIS Drawer (4 PU)	Min: - 2.00 Max: + 2.00	Min: + 9.50 Max: + 15.60	Min: - 1.5 Max: + 1.5

NOTES:
1. Center of gravity coordinate system originates from the intersection of the back face of the front panel flange with the centerline of the slides. Axes are parallel to the ISPR coordinate system defined in Figure 3-2.
2. Total maximum integrated mass (including drawer, contents, and slides) on any one set of slides is limited to 64 lb.
3. The approximate weight of the stowage drawer is 20 lb and for the powered drawer is 26 lb.

3.4.4.2 Powered ISIS Drawers

The powered ISIS drawer is intended for rigidly attached payloads. The powered ISIS drawer design makes no provision for on-orbit access to contained payloads. The top is bolted on with non-captive fasteners and not intended for on-orbit removal.

Receptacle-type power and data connectors are hard-mounted on the rear panel of the drawer chassis. Air inlet and outlet openings are provided on the sides and back of the chassis respectively for use of a payload-provided fan. Connector positions and air inlet and outlet locations are shown in Figure 3-19. Connector part numbers and pin functions are detailed in Section 9.

PDs are allowed to make limited modifications to the powered ISIS drawer. Modifications should be approved by the rack integrator prior to incorporation.

The powered ISIS drawer weighs approximately 26 lb.

A. The total mass of payload in a powered ISIS drawer shall not exceed 38 lb.

B. The total mass and center of gravity of the integrated powered ISIS drawer shall comply with the limits given in Table 3- IV.

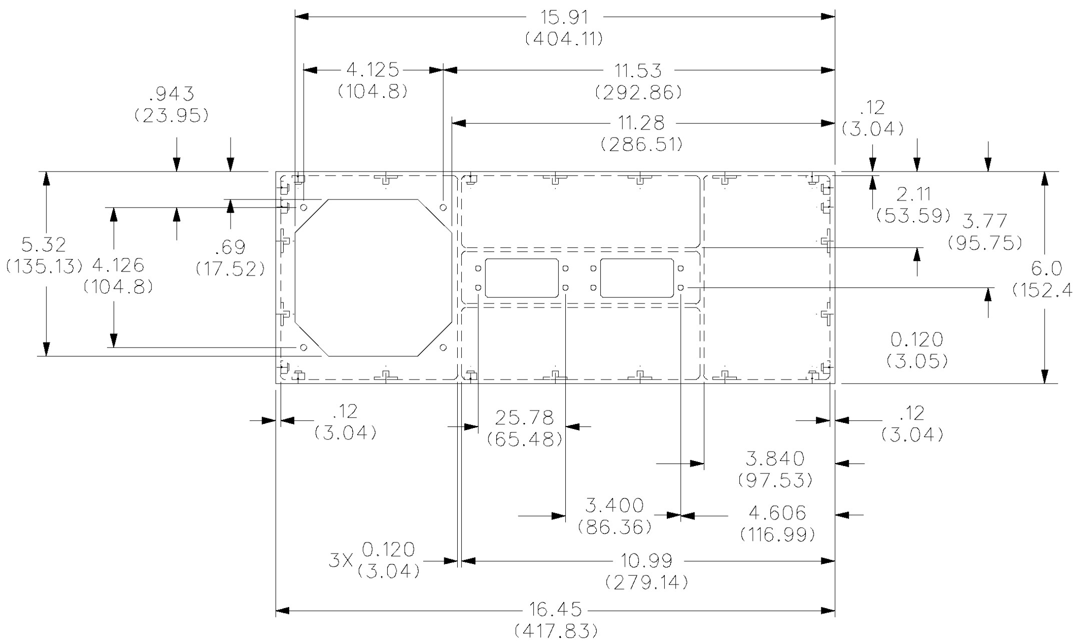
C. The front of the powered ISIS drawer provides a removable panel as shown in Figure 3-20. This panel may be modified or replaced by the PD. Modifications to the front panel shall be within the area illustrated in Figure 3-20, and shall be flush to the front surface of the panel.

D. The powered ISIS drawer is provided with a blank bottom plate (see Figure 3-21) for PD use to attach equipment items. Mounting shall be done through the bottom plate ribs. Fasteners used to attach hardware to the bottom plate shall be no larger than #10 size. Fasteners shall be installed either through the experiment into inserts installed in the bottom plate, or through the bottom plate into nuts or inserts in the experiment.

E. Fasteners engaging inserts in the bottom plate shall be sized not to extend beyond the bottom surface of the bottom plate. Fasteners installed from the outside of the drawer through the bottom plate shall have 100° countersunk heads set flush with the bottom surface of the bottom plate.

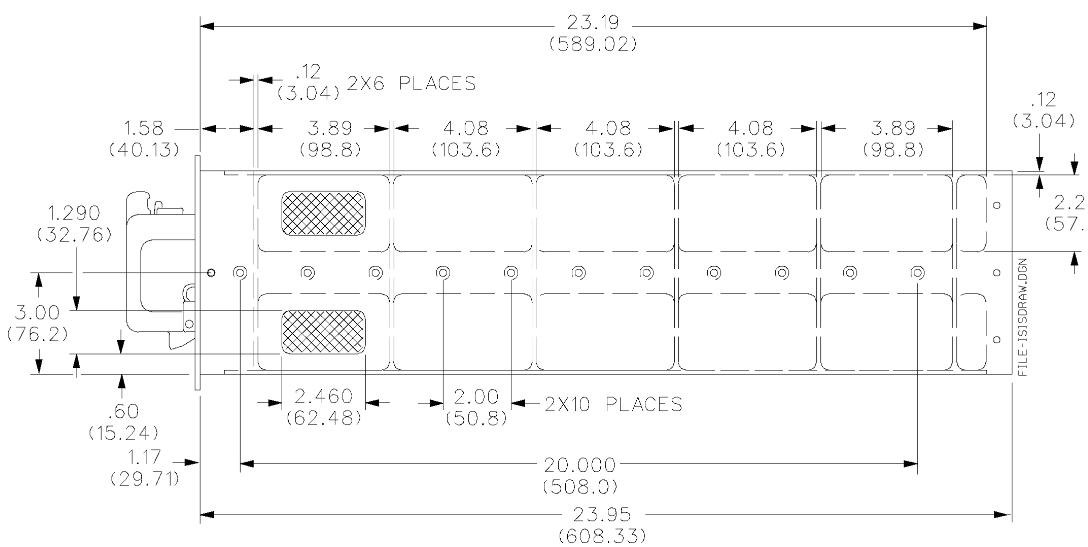
F. The PD shall verify the structural dynamics and integrity of the ISIS drawer per Sections 4.1 through 4.5 of this document and SSP 52005 following modifications to accommodate the attachment of payload. A NASTRAN finite element model of the unmodified powered ISIS drawer is available for use in this analysis.

G. Material selection and processing for modification of the powered ISIS drawer shall be per Section 13.1 of this document.



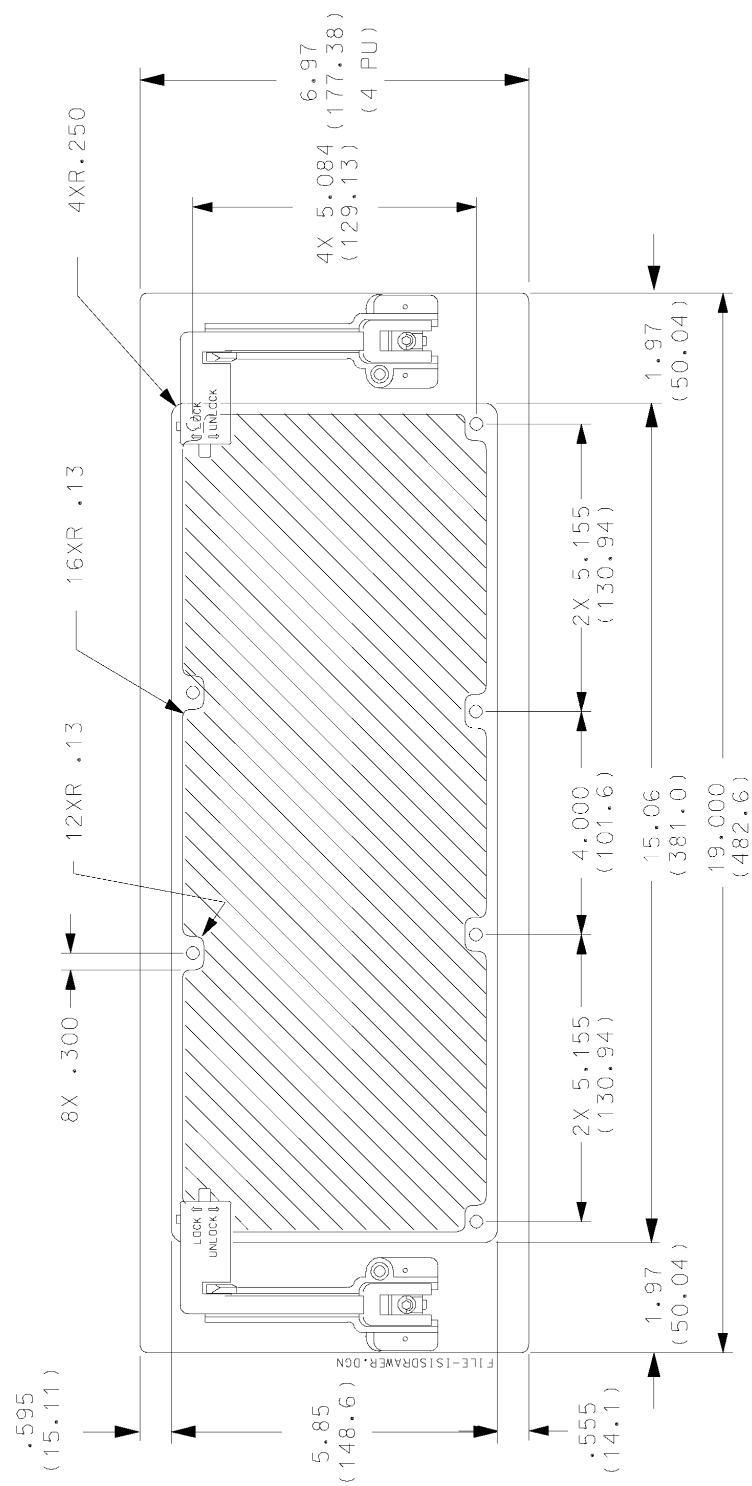
Rear View Of 4 PU ISIS Drawer

Note:
Dimensions are in inches (mm).



Air Inlet Locations (Side View)

FIGURE 3-19 ISIS DRAWER POWER, DATA CONNECTORS, AND FAN INLET/EXHAUST LOCATIONS



Notes:
1. All Dimensions are in inches (mm).
2. Panel Material is 6061-T6 (Aluminum)
3. Panel Thickness is 0.090 in (2.28)
4. Modifiable area is shaded. (See Sheet 2)

FIGURE 3-20 MODIFIABLE PORTION OF 4-PU ISIS DRAWER FRONT (Sheet 1 of 2)

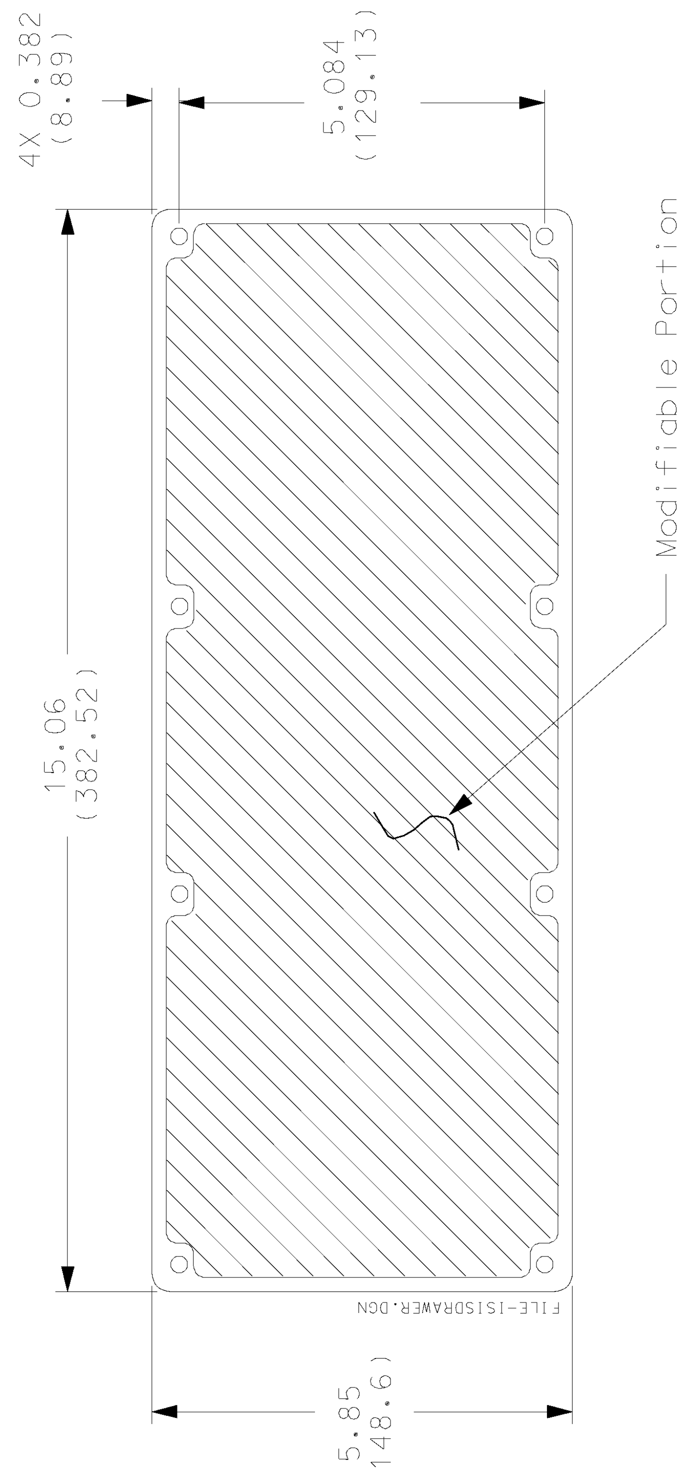


FIGURE 3-20 MODIFIABLE PORTION OF 4-PU ISIS DRAWER FRONT (Sheet 2 of 2)

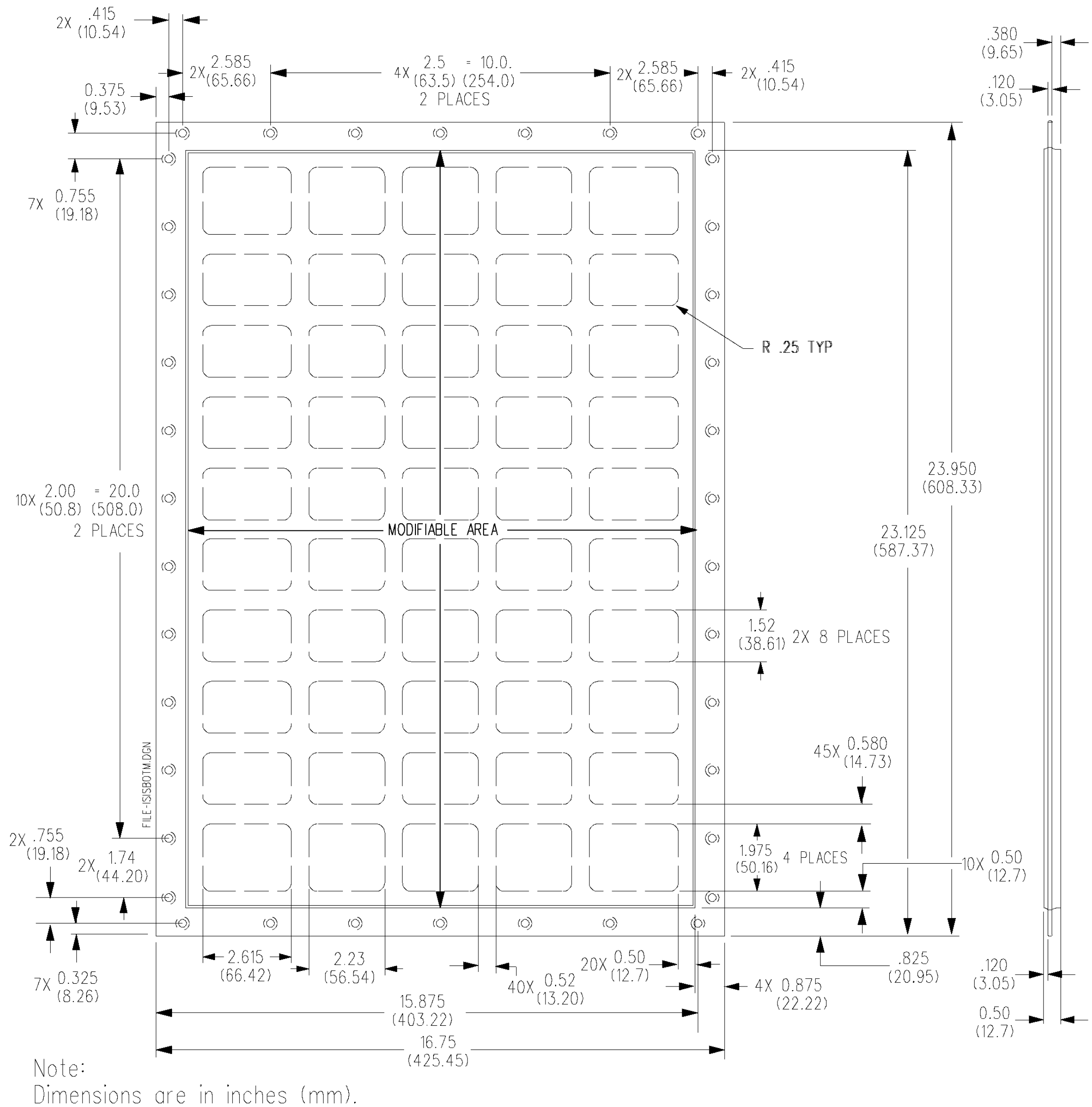


FIGURE 3-21 ISIS DRAWER BOTTOM PLATE

3.4.4.3 ISIS Drawer Replacement

Replacements for ISIS drawers must be discussed with the rack integrator prior to implementation. Information on requirements for PD-provided ISIS drawers can be found in ISIS-01 and ISIS-02.

3.4.5 Securing of Threaded Fasteners

Threaded fasteners connecting safety-critical structures (SCS) shall use a means of positive locking.

***Design Guidance*:** Drawings should clearly depict the safety wiring or safety cable method and configuration used (per MS33540 as applicable). Reference paragraph 3.6.3 for disposition of sharp edges. Threaded inserts should be used in applications that require tapped holes in aluminum, magnesium, plastics, or other materials that are susceptible to galling or thread damage. When self-locking features are used, the screw length should be sufficient to fully engage the locking device with a minimum of two thread protrusion through the locking mechanism. When self-locking devices are used, an allowable range of running torque, or the maximum number of reuses that would still ensure an adequate lock, should be specified. Spring-type or star-type lock washers should not be used. Adjustable fittings or mounting plates which use oversized holes or slotted holes to provide adjustment should not be dependent upon friction between the fitting or mounting plate and the mounting surface to provide locking. Diamond-type serrations should not be used.

3.4.5.1 Fracture-Critical Threaded Fasteners

Fracture-critical threaded fasteners (and threaded fasteners used in an application of retaining a rotating device) shall be safety cabled or cotter pinned. Note safety wire could be used if on-orbit removal is not required.

***Design Guidance*:** Random vibration testing of the as-used configuration may not be used to justify a waiver to this requirement.

3.4.5.2 Redundant Threaded Fasteners Locking Requirements

A. Redundant threaded fasteners (non-fracture critical) in habitable areas or removable on orbit shall employ self-locking threaded devices or approved locking compounds.

B. Self-locking threaded devices shall meet the requirements of MIL-STD-1312-7 (or equivalent).

C. Locking compounds shall be selected from MSFC-HDBK-527/JSC-09604 (or equivalent).

D. Locking compounds shall not be used in areas where excess compound could migrate to surfaces which must remain free to move.

E. Self-locking devices which can generate debris shall be avoided in applications where particulate contamination may cause damage or degradation to the equipment or vehicle.

F. Redundant threaded fasteners (non-fracture critical) not in a habitable area and not removable on orbit shall employ safety wire, safety cable, cotter pins, built-in self-locking features, or approved thread-locking compounds.

***Design Guidance*:** Random vibration testing of the as-used configuration may be used as supporting data to request a waiver to this requirement.

3.5 GROUND SUPPORT EQUIPMENT (GSE)

3.5.1 Ground Handling

Ground handling of hardware without handles, particularly if the items are heavy and bulky, becomes difficult if the items must be stowed at the launch pad. To facilitate this handling process, GSE receptacles (PN MD-122-0012-004) and rivets (PN NAS 1198-4-4) could be incorporated in the user's hardware. A limited supply of GSE receptacles has been stocked by JSC to support PDs as an optional service. These receptacles, shown in Figure 3-22, can be used either with a T-handle or with a single handle. It should be noted that for a single handle, the receptacles must be accurately spaced on the experiment hardware. See handle configuration in Figure 3-22.

3.5.2 MPLM Late/Early Access Requirements

The requirements contained in this section define and control the ISS MPLM late/early access for payloads and associated GSE. Additional program-provided late/early access GSE data is referenced in SSP 50053, ASI Flight Hardware to Launch and Landing Site ICD; ICD-A-21378, SSP DEAP to ISSP HAS/CHEK GSE Interfaces; ICD-A-21379, ISS Payload/GSE Ground Operations Envelope.

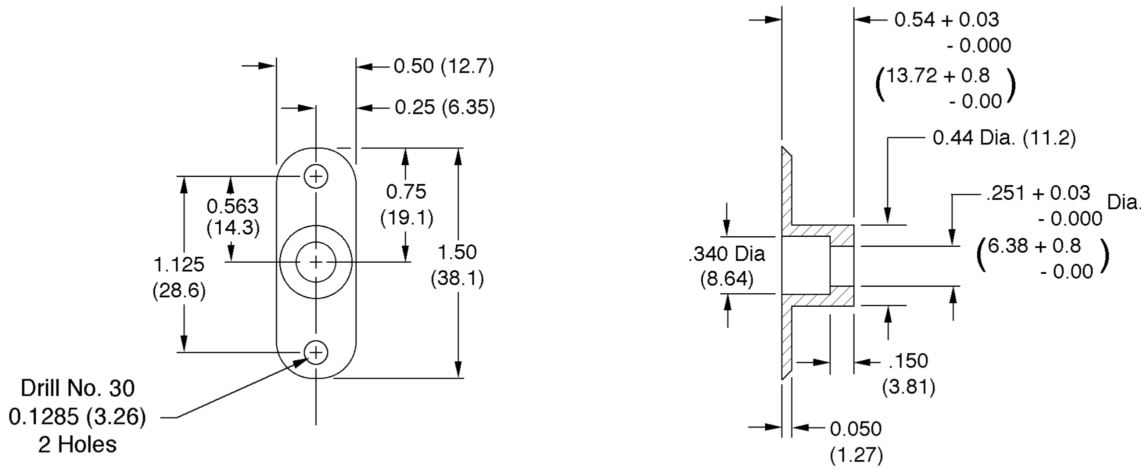
Late access is defined as cargo integration during pre-launch activities with the orbiter in the vertical position. Late access for stowage of conditioned samples inside the MPLM is completed by L-88 hours, and is followed by MPLM late access GSE removal.

Early access is defined as cargo deintegration during post-landing activities with the orbiter in the horizontal position. Payload activities will begin approximately 96 hours after landing/return (R+96).

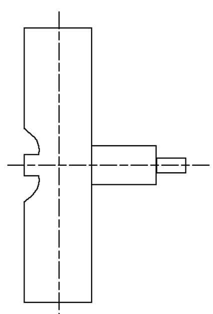
MPLM late/early access payloads, equipment items, samples, and associated GSE weight shall not exceed 250 lb per individual transfer.

3.5.2.1 MPLM Late Access Envelope (Kennedy Space Flight Center (KSC))

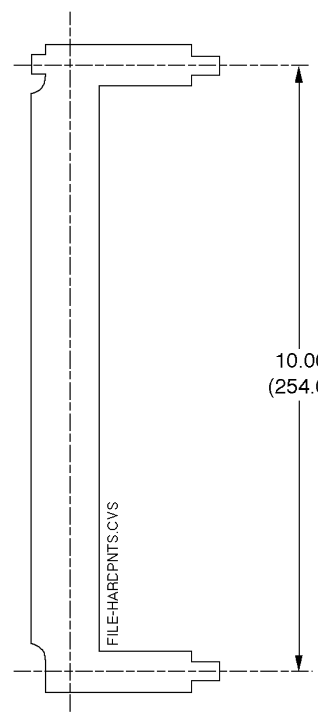
A. Payloads, equipment items, samples, and associated GSE requiring MPLM late access shall comply with the hatch envelope defined in Figure 3-23.



Receptacle - Plan View **Receptacle - Side View**



T-Handle



Notes:
1. Maximum Panel weight when using GSE Handles is 50 lb (22.7 kg).
2. Dimensions are in inches (mm).
3. Handles are supplied by the Space Shuttle Program at KSC
4. This is applicable to Orbiter Middeck-mounted payloads only.

U-Handle

FIGURE 3-22 PAYLOAD/GSE HARDPOINTS (CONTROLLED IN MIDDECK IDD)

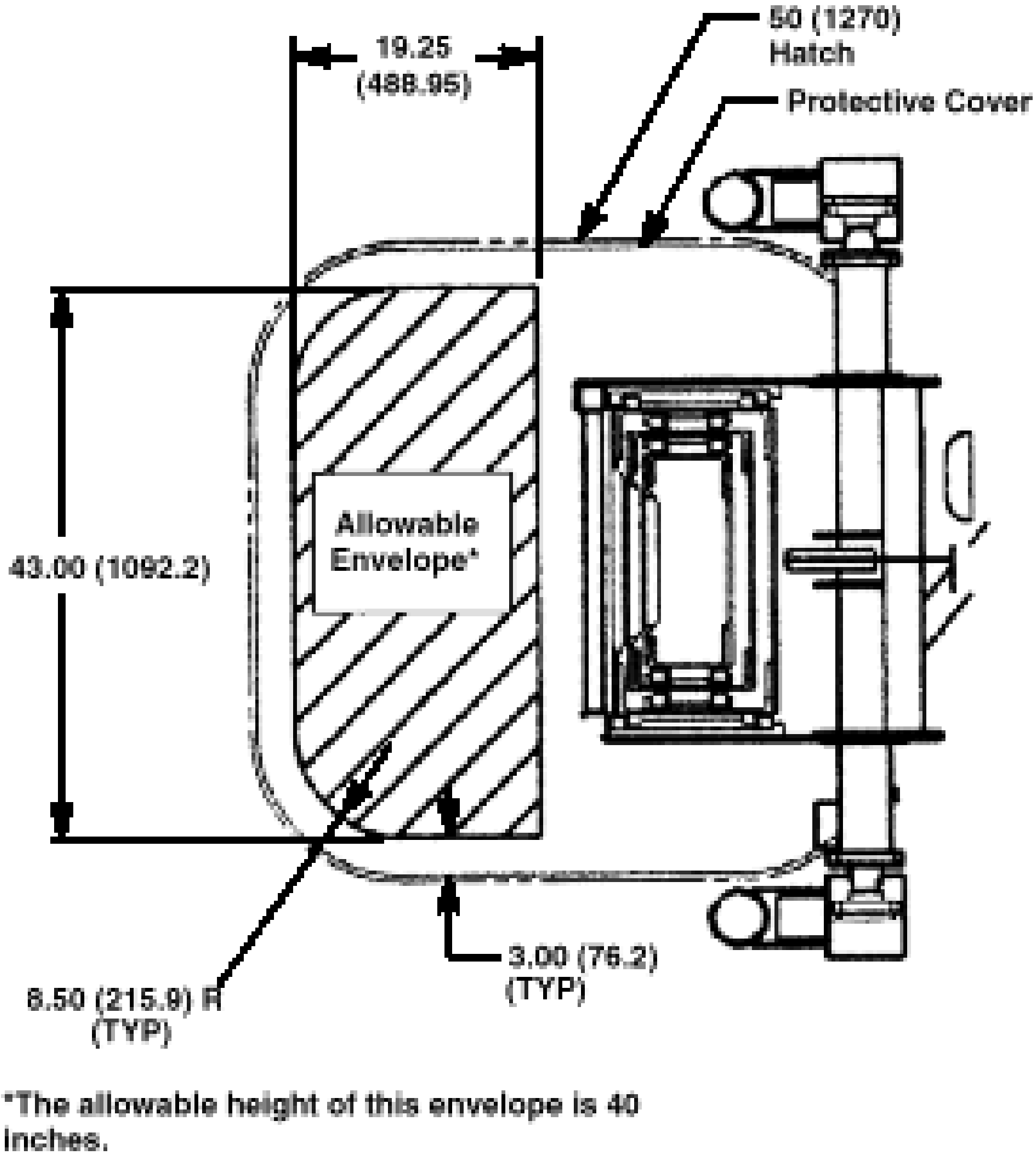


FIGURE 3-23 LATE ACCESS PAYLOAD ENVELOPE

B. Payloads, equipment items, samples, and associated GSE requiring MPLM late access shall comply with the late access hoist hook interface defined in Figure 3-24.

C. Payloads, equipment items, samples, and associated GSE requiring MPLM late access shall comply with the late access monorail hook hoist interface defined in Figure 3-25.

3.5.2.2 MPLM Early Access Envelopes (KSC and Dryden Flight Research Center (DFRC))

A. Payloads, equipment items, samples, and associated GSE requiring MPLM early access shall comply with the Orbiter Docking System (ODS) envelope defined in Figure 3-26.

B. Payloads, equipment items, samples, and associated GSE requiring MPLM early access shall comply with the Dryden Early Access Platform (DEAP) monorail interface defined in Figure 3-27.

3.6 ENVELOPE REQUIREMENTS

3.6.1 Payload Static Envelopes

Payload hardware design must not violate the static envelope dimensions shown in the following figures:

A. 4-PU ISIS drawers envelope shall be as shown in Figure 3-17 (as applicable).

B. MDLs or MDL replacement payloads envelope shall be as shown in Figures 3-5, 3-6, 3-9, 3-10, 3-11, 3-12, 3-13, and 3-14 (as applicable).

C. MDL replacement item attachment hardware envelope shall be as shown in Figures 3-5, 3-9, 3-10, 3-11, 3-12, 3-13, and 3-14 (as applicable).

3.6.2 On-Orbit Payload Protrusions

The requirements in this section apply to installation and operation activities, but not to maintenance activities.

Note: The on-orbit protrusion requirements in this section are applicable to when the payload is on orbit and do not apply to other phases of the transportation of the payload (e.g., launch, landing, MPLM installation).

A. On-orbit protrusions, excluding momentary protrusions, shall not extend laterally across the edges of the rack or pass between racks.

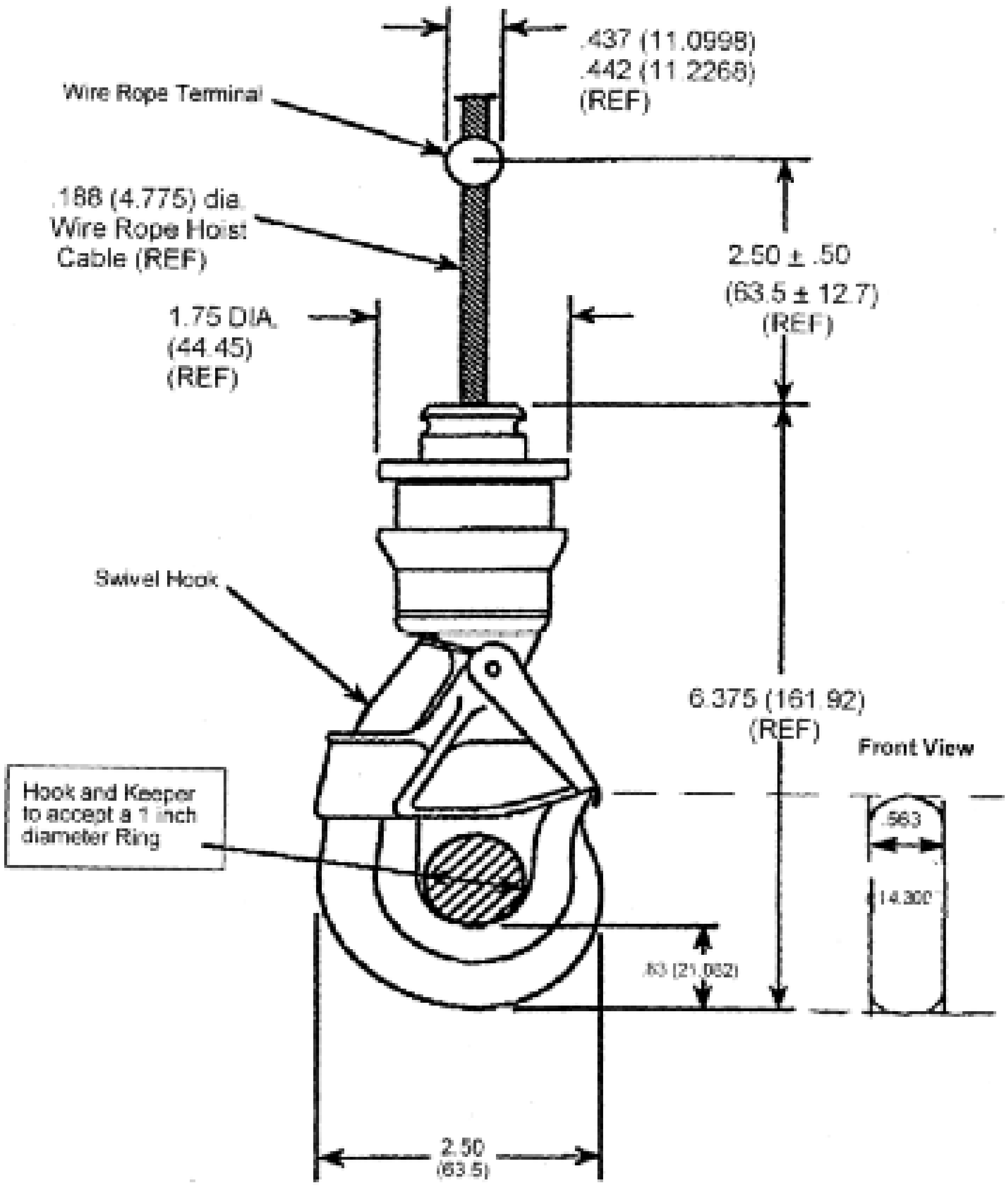
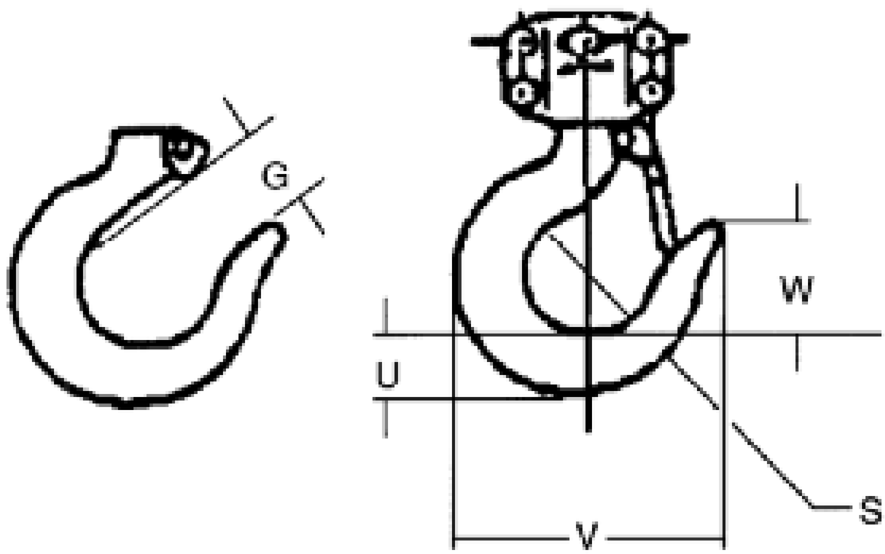


FIGURE 3-24 LATE ACCESS HOIST HOOK



Dimensions (inches and mm)				
G	S	U	V	W
1.062 (26.975)	1.687 (42.85)	1.062 (26.975)	3 (76.2)	1.375 (34.925)

FIGURE 3-25 LATE ACCESS MONORAIL HOIST HOOK

B. The payload hardware, excluding momentary protrusions, shall not prevent attachment of Rack Mobility Aid (RMA) on any seat track attach holes.

Constraints which may be associated with payload protrusions include:

(1) Removal of the protrusion during rack installation, translation, and crew translation

(2) Removal of the protrusion if RMA is installed on the rack

(3) Removal of the protrusion to prevent interference with microgravity operations

(4) Removal or powering off of the rack if the protrusion blocks Portable Fire Extinguisher (PFE) access or the fire indicator

(5) Limiting the payload location, e.g., protrusions located in the floor and the ceiling are limited to a total of no more than 12 in.

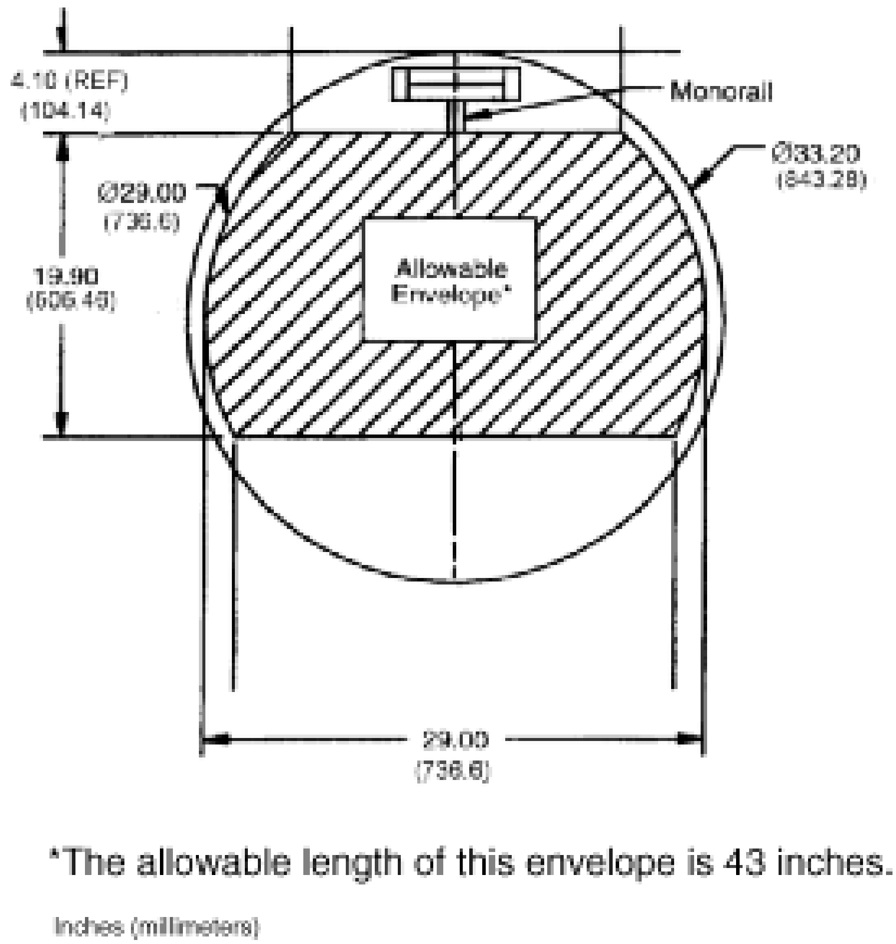


FIGURE 3-26 EARLY ACCESS PAYLOAD ENVELOPE

As is indicated by the constraints above, protrusions have a negative impact on crew operations and are to be minimized.

3.6.2.1 Front Face Protrusions (Permanent)

Permanently attached equipment shall not protrude beyond the plane of the NASA ISPR front face GSE attachments which are 24.6 in (62.5 cm) from the backplate of the EXPRESS Rack. Use of this maximum dimension will require a waiver. Payload protrusions of a permanent nature in the X-direction exceeding those defined in paragraphs 3.4.3.1, 3.4.3.2, 3.4.3.3, and 3.4.3.4 require prior approval via the PIRN process before inclusions into any payload-unique ICD due to differences in capabilities between the middeck and the EXPRESS Rack. See Figure 3-17.

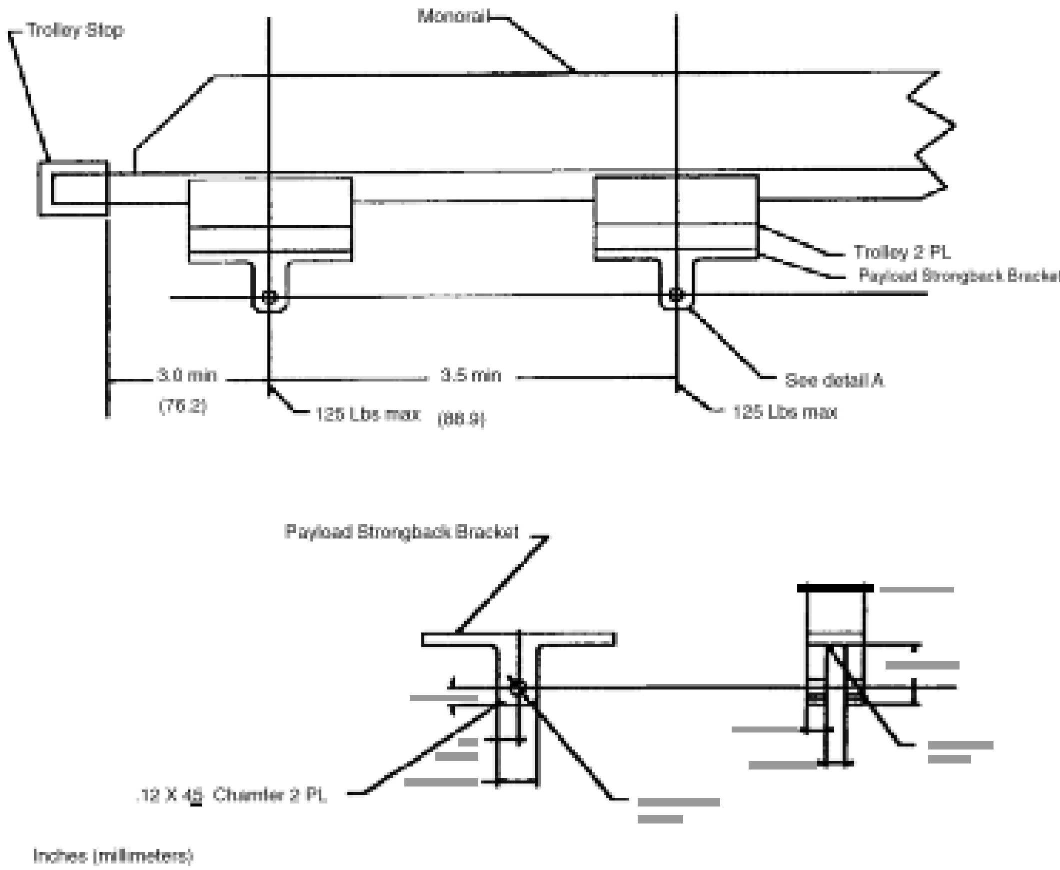


FIGURE 3-27 EARLY ACCESS DEAP MONORAIL INTERFACE

3.6.2.2 On-Orbit Semi-Permanent Protrusions

An on-orbit semi-permanent protrusion is defined as a payload hardware item which is typically left in place but can be removed by the crew with hand operations or standard IVA tools.

A. On-orbit semi-permanent protrusions shall be limited to 1.3 in beyond the plane of the NASA ISPR front face GSE attachment points (i.e., GSE plane).

B. All on-orbit semi-permanent protrusions shall be designed to be removable by the crew with hand operations and/or standard Intravehicular Activity (IVA) tools.

3.6.2.3 On-Orbit Temporary Protrusions

An on-orbit temporary protrusion is defined as a payload hardware item which is typically located in the aisle for experiment purposes only. These items should be returned to their stowed configuration when not being used.

A. On-orbit temporary protrusions shall be limited to 17 in beyond the GSE plane (except for payloads located in the floor or ceiling which are limited to 6 in each or a total of 12 in for both floor and ceiling).

B. The combination of all on-orbit temporary protrusions for the integrated rack shall be designed such that they can be eliminated or returned to their stowed configuration by the crew with hand operations and/or standard IVA tools within 10 minutes.

Design Guidance: PDs should be aware that the further their temporary extensions protrude into the ISS aisle, the greater their placement constraints (both physical and duration) within a specific ISS laboratory. Translation paths are defined as a “rounded rectangular volume” centered in the ISS laboratory with dimensions of 72 in (182.9 cm) by 32 in (81.3 cm) and a 50 in (127 cm) square volume centered in the ISS laboratory.

3.6.2.4 On-Orbit Momentary Protrusions

On-orbit momentary protrusions are defined as payload obstructions which typically would protrude for a very short time or could be readily eliminated by the crew at any time. Momentary protrusions include only the following: drawer/door/cover replacement or closure.

On-orbit momentary protrusions shall be designed such that they can be eliminated within 30 seconds.

3.6.2.5 On-Orbit Protrusions for Keep-Alive Payloads

On-orbit protrusions for keep-alive payloads are defined as protrusions which support and/or provide the uninterrupted resources necessary to run an experiment. On-orbit protrusions for keep-alive payloads include only power/data cables and thermal hoses.

On-orbit protrusions for keep-alive payloads shall be limited to 1.8 in beyond the GSE plane.

Design Guidance: On-orbit semi-permanent protrusions and protrusions for keep-alive payloads should be minimized since the sum of these protrusions for the integrated rack is limited to no more than 500 in^2.

3.6.3 Sharp Edges and Corners

Payload design within a pressurized module shall protect crewmembers from sharp edges and corners during all crew operations in accordance with NSTS 1700.7, ISS Addendum, paragraph 222.1.

3.6.3.1 Protective Covers/Shields

Equipment (mounted, portable, loose, or accessible during maintenance operations) which does not meet the corner and edge requirements of 3.6.3 shall be covered or shielded.

3.6.3.2 Holes

Holes that are round or slotted in the range of 0.4 to 1.0 in (10.0 to 25.0 mm) shall be covered to prevent crew exposure to sharp surfaces and to prevent debris from entering the hole.

3.6.3.3 Screws/Bolts Ends

Threaded ends of screws and bolts accessible by the crew and extending more than 0.12 in (3.0 mm) shall be covered or capped to protect against sharp threads. Materials that flake or create debris if the screw/bolt has to be removed should be avoided.

3.6.3.4 Burrs

Exposed surfaces shall be free of burrs.

3.6.3.5 Latches

Latches that pivot, retract, or flex so that a gap of less than 1.4 in (35 mm) exists shall be designed to prevent entrapment of a crewmember’s fingers or hand. Note: The ISIS drawer latches meet this requirement.

3.6.3.6 Levers, Cranks, Hooks, and Controls

Levers, cranks, hooks, and controls shall not be located or oriented such that they can pinch, snag, or cut the crewmember.

3.6.3.7 Safety/Lockwire

Safety wires or lockwire shall not be used on fasteners exposed to the cabin except as required by SSP 52005, paragraph 5.6. (Also see paragraph 3.4.3.6.4.)

3.6.3.8 Securing Pins

Securing pins shall be designed to prevent their inadvertently backing out above the handhold surface.

3.6.4 Pressure Relief Device Location

Subrack payloads shall not have a pressure relief device on the front of the subrack payload.

3.7 MECHANICAL INTERFACES FOR CREW RESTRAINTS AND MOBILITY AIDS

3.7.1 Hardware Definition

Seat tracks are provided as part of the EXPRESS Rack facility/ISPR and can be used to facilitate on-orbit crew operations. Payloads should not plan to affix things to the rack seat tracks as these are the primary attachment locations for crew restraints and mobility aids which must be moved. Other hardware items must be provided by the PD; however, the ISS may provide some items for standardization (foot restraints, handrails, tethers, etc.). Request for any ISS-provided hardware must be identified in the payload-unique EIA.

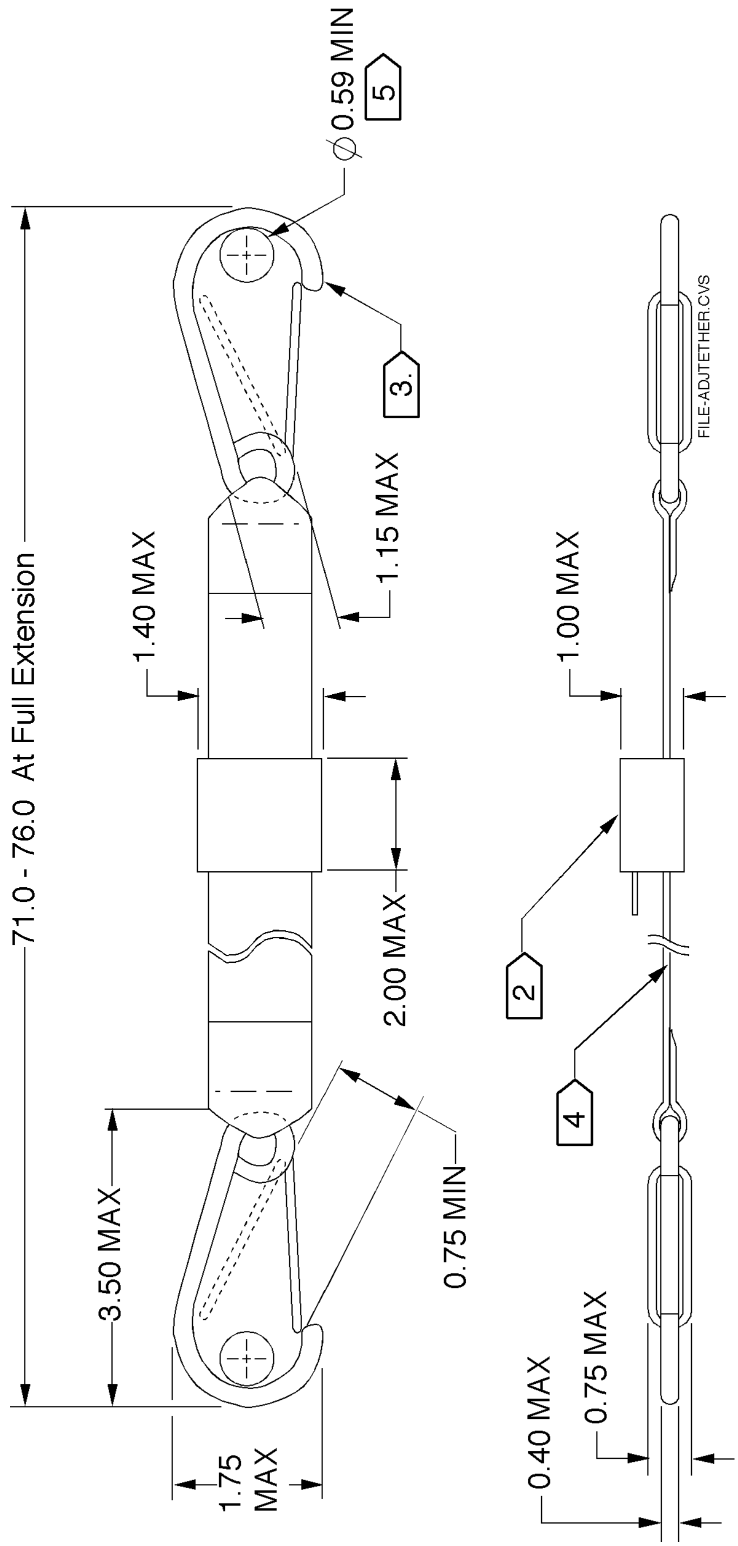
3.7.2 Interface Compatibility

PD hardware shall be compatible with (not interfere with nominal installation, use, and removal) crew operational aids, mobility aids, and crew restraints in accordance with ICD SSP 30257:004. For convenience some of the items are shown in Figure 3-28 (Adjustable Tether), Figure 3-29 (Tether), Figure 3-30 (Handrail), and Figure 3-31 (Seat Tracks).

3.8 IVA TRANSFER PATHWAY

EXPRESS Rack payloads to be transferred to/from ISS laboratories and the orbiter shall be limited to the dimensions in Sections 3.4.3 and 3.6.2 due to IVA transfer pathway limitations.

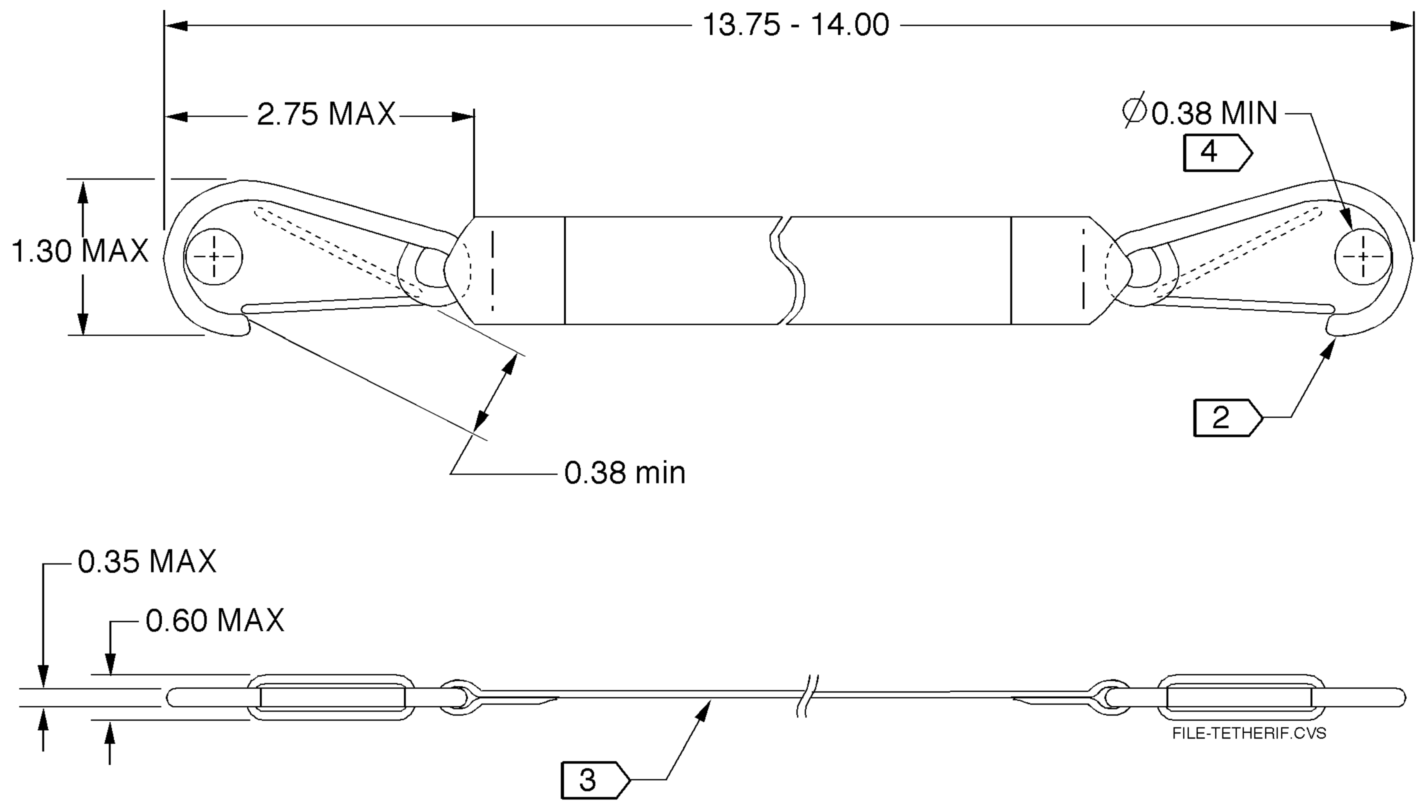
Middeck payloads to be transferred to/from ISS shall be limited to 18.125 in (width) by 21.88 in (depth) by 21.062 in (length) [460.4 mm (width) by 555.6 mm (depth) by 535.0 (length)] dimensions due to IVA transfer pathway limitations. Payloads requiring handholds for transfer operation will require a unique clearance assessment if they violate the maximum allowable dimensions. Note: 29.5 inches is the largest clean diameter for transfer through the Shuttle/ISS hatches.



NOTES:

1. All dimensions are in inches. Drawing not to scale
2. Length adjustment mechanism.
3. Tether hook will be carbine hook style.
4. Tether Strap
5. Eye Hook minimum clearance.

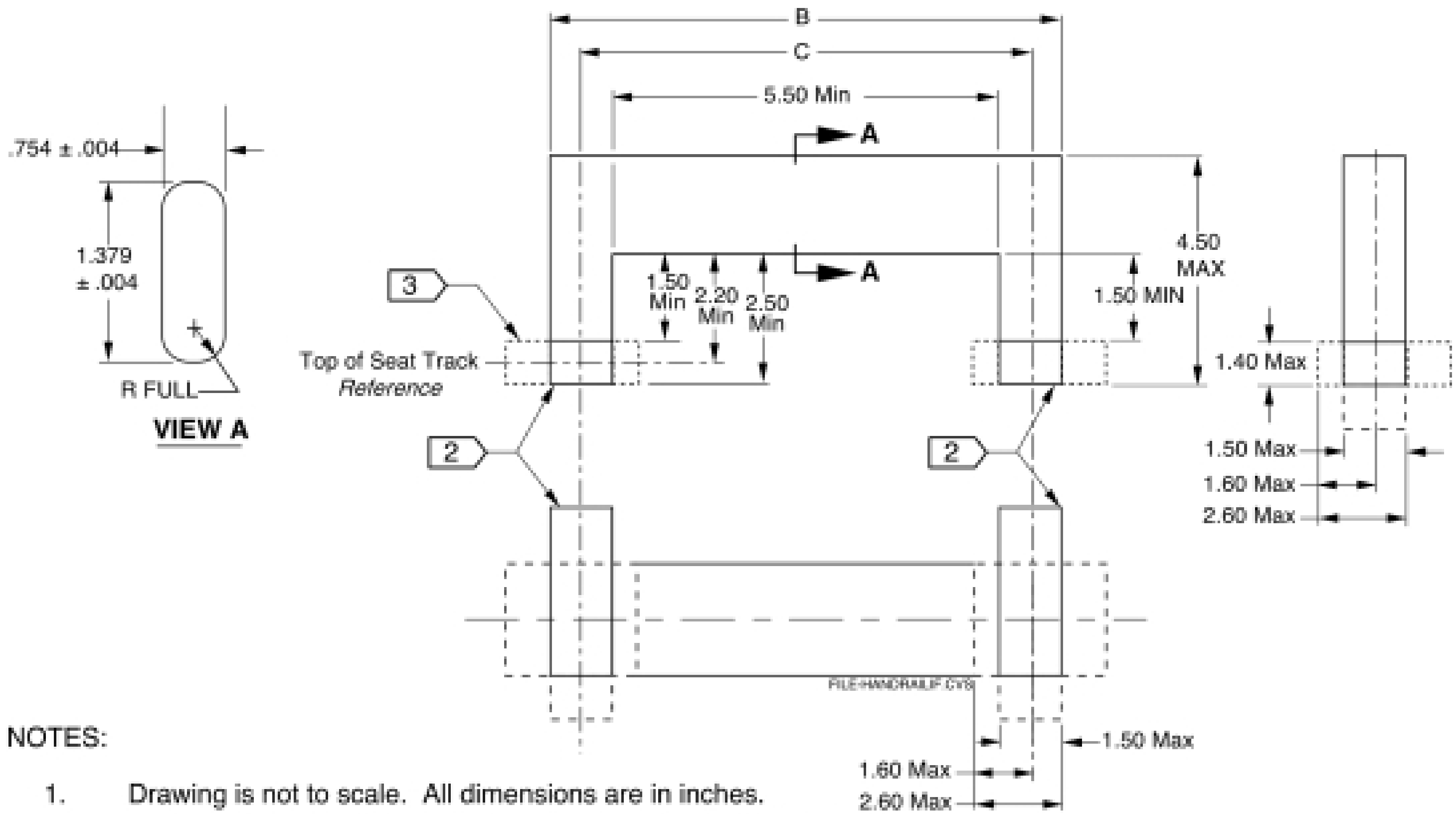
FIGURE 3-28 ADJUSTABLE TETHER INTERFACE DRAWING (SHOWN FOR REFERENCE ONLY)



NOTES:

1. All dimensions are in inches. Drawing is not to scale
2. Tether hook will be carbine hook style.
3. Tether Strap
4. Eye Hook minimum clearance.

FIGURE 3-29 TETHER INTERFACE DRAWING (SHOWN FOR REFERENCR ONLY)



NOTES:

1. Drawing is not to scale. All dimensions are in inches.

2. Interfacing surface shall be mechanically compatible with the seat track part geometry defined in SSP 41017.

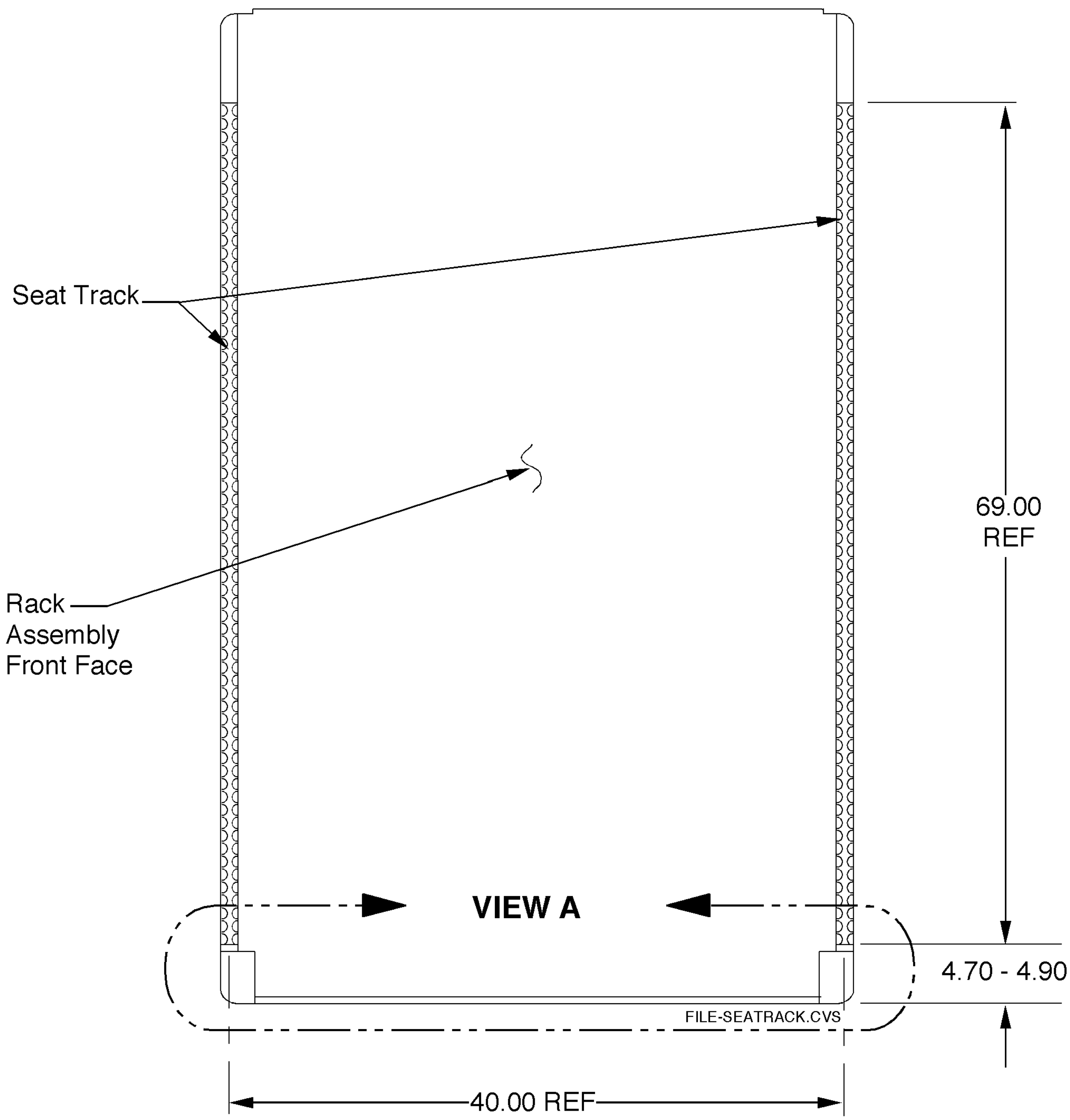
3. Envelope of seat track attachment mechanism. Mechanism is relocatable every 90°.

4. Maximum dimension for attachment to seat tracks parallel to each other per Figure 3-32.

5. Nominal centerline to centerline.

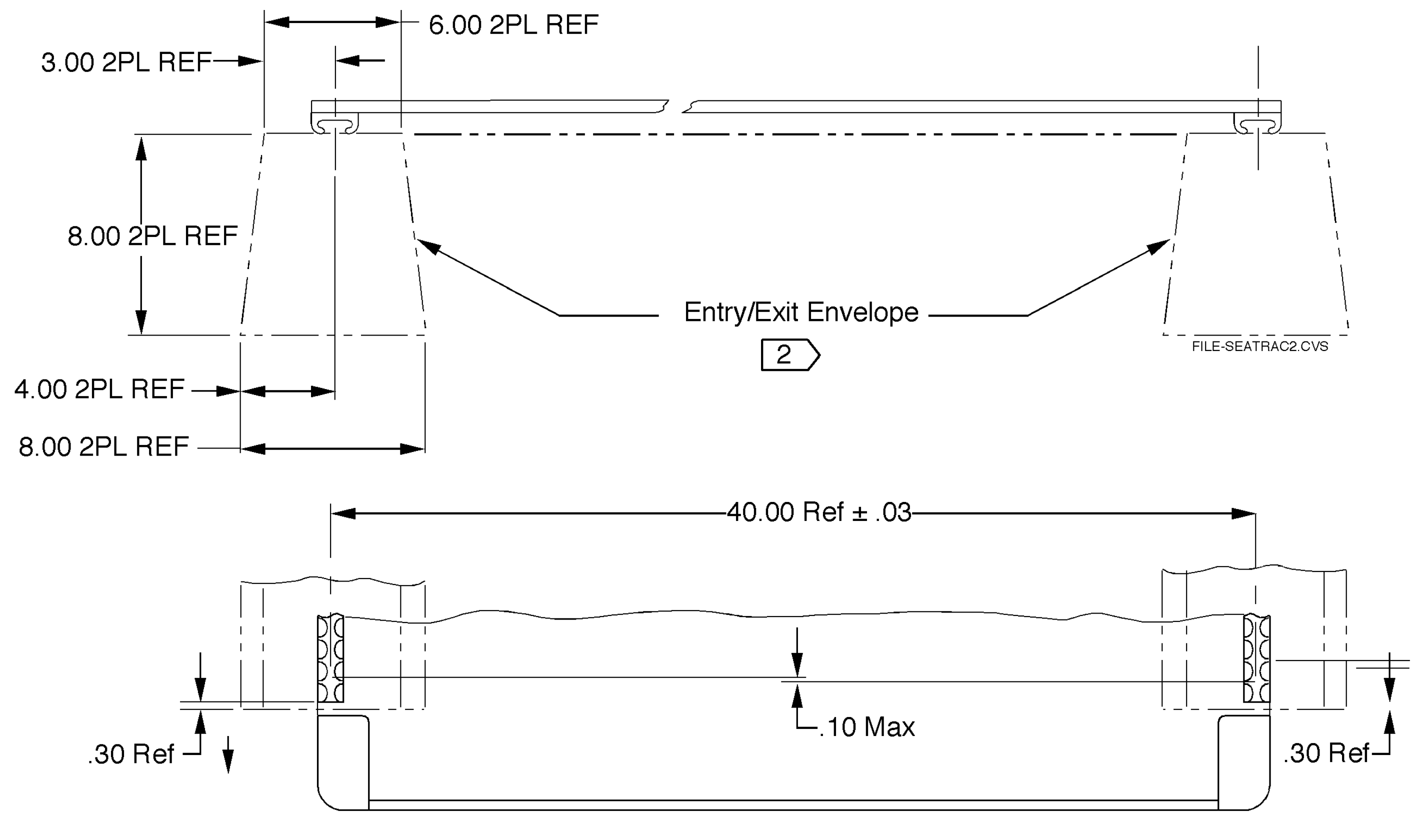
Handrail	B 4	C 5
41.5 Handrail	41.5	40.0
21.5 Handrail	21.5	20.0
8.5 Handrail	8.5	7.0

FIGURE 3-30 HANDRAIL INTERFACE DRAWING (SHOWN FOR REFERENCE ONLY)



NOTE: All Dimensions are in inches.

FIGURE 3-31 SEAT TRACK LOCATIONS FOR RACK ASSEMBLY FRONT FACE (SHOWN FOR REFERENCE ONLY) (Sheet 1 of 3)



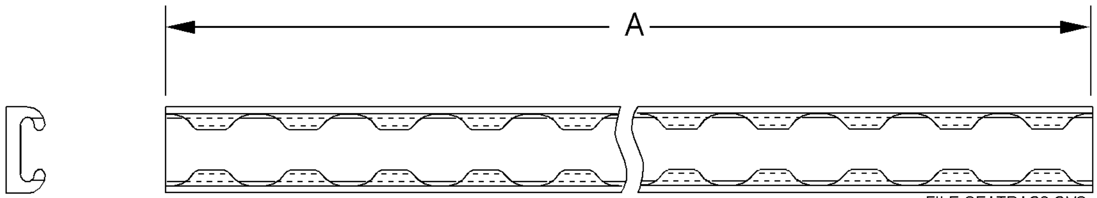
VIEW A

NOTES:

1. All dimensions are in inches.

2. No hardware shall be packaged/mounted inside the Entry/Exit Envelope. The envelope provides access capability of a crewmember's hand for R&MA seat track attachment/detachment actuation.

FIGURE 3-31 SEAT TRACK LOCATIONS FOR RACK ASSEMBLY FRONT FACE (SHOWN FOR REFERENCE ONLY) (Sheet 2 of 3)



Seat Track Lengths

Seat Track Part Location Title	DIM "A"	
Rack Front Faces	69.00	3
Rack Back Faces	6.00	4
Module Secondary Structure Portable Equipment/ORUs	1.62	4

NOTES:

1. All dimensions are in inches.

2. Seat Track part geometry defined in SSP 41017.

3 Minimum

4 +.06/-.00

FIGURE 3-31 SEAT TRACK LENGTH CONFIGURATION (SHOWN FOR REFERENCE ONLY) (Sheet 3 of 3)

3.9 ORBITER OVERHEAD WINDOW INTERFACE REQUIREMENTS

Payloads which require use of the orbiter overhead window(s) shall comply with the requirements of NSTS 21000-IDD-MDK, paragraph 3.11.

SECTION 4, STRUCTURAL INTERFACES

4.1 OPERATIONAL LOADS

4.1.1 Component Frequency

EXPRESS Rack-mounted equipment (integrated ISIS drawer, integrated MDL, or MDL replacement) shall have a first primary natural frequency greater than 35 Hz during launch and landing phases. Evaluation of this requirement shall be based on rigidly mounting the component at the component-to-rack interface. “Component” refers to integrated MDL, ISIS drawer(s), and any MDL or ISIS drawer replacement item.

Middeck payloads not stored in an MDL shall have natural frequencies greater than 30 Hz with respect to their orbiter attachment interface.

4.1.2 Payload Low Frequency Launch and Landing Loads

Payload hardware shall be designed to maintain positive margins of safety during lift-off and landing events. The loads are defined in Table 4-I. The methodology for combining loads and evaluating lift-off and landing events is defined in SSP 52005.

4.2 EMERGENCY LANDING LOADS FACTORS

4.2.1 Middeck

Emergency landing load factors specified in Table 4-II shall be used for payload elements mounted in the middeck. They apply to components whose failure could result in injury to personnel or prevent egress from the vehicle. These load factors act independently, and the longitudinal load factor (Nx) is directed in all directions within 20° of the longitudinal axis (see Figure 4-1). Load factors associated with emergency landing events for payload hardware flown in the MPLM are enveloped by load factors defined in Table 4-I.

4.3 RANDOM VIBRATION

4.3.1 Random Vibration - MPLM

The random vibration environment for components mounted to MDL locations (i.e., EXPRESS backplate) is shown in Table 4-III and is independent of component weight. The random vibration environment for the integrated ISIS drawers is shown in Table 4-IV and is independent of weight. The random vibration environment for the components mounted to the ISIS drawer (baseplate, side, front panel, etc.) is shown in Table 4-V and is independent

TABLE 4-I EXPRESS RACK PAYLOAD TRANSIENT RESPONSE LOAD FACTORS (g's)

LOAD FACTOR	LIMIT LOAD FACTORS		
	X	Y	Z
Lift-off	±11.6	±7.7	±9.9
Landing	±9.5	±5.4	±12.50

NOTES:

1. Since the load factors are given in the crew module coordinates system, care should be taken to follow the load combinations shown in Section 4.0 of SSP 52005.
2. Load factor is defined as the total external applied force divided by the corresponding total component weight and carries the sign of the externally force in accordance with the orbiter coordinate system.
3. The sign convention is illustrated in Figure 4-1.

TABLE 4-II EMERGENCY LANDING LOAD FACTORS

ULTIMATE INERTIA LOAD FACTORS		
Nx	Ny	Nz
+20.0 -3.3	+3.3 -3.3	+10.0 -4.4

NOTES:

1. Sign convention follows that of the crew module coordinate system.
2. Emergency landing load factors are ultimate. The longitudinal load factors are directed in all afward azimuths within a cone of 20 degrees half-angle.
3. The specified load factors will operate independently.
4. Load factors are defined as opposite in sign from accelerations.
5. For reference only. These loads are controlled in NSTS 21000-IDD-MDK (Table 4.2-1).

of weight. The sign convention of the load factors is defined in Figure 4-1. The methodology for combining loads and evaluating lift-off and landing events is defined in SSP 52005. All payload equipment shall be shown to have positive margins of safety with the specified loads.

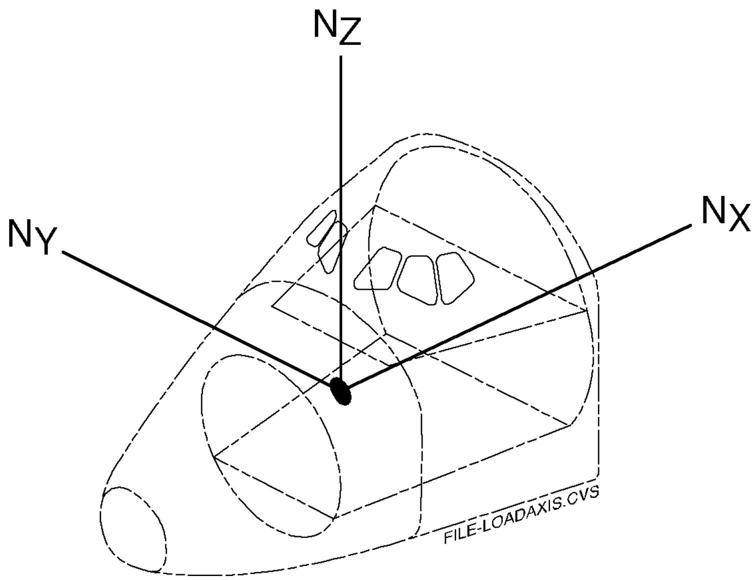


FIGURE 4-1 DIRECTIONS OF LOAD FACTORS

TABLE 4-III HIGH FREQUENCY RANDOM VIBRATION ENVIRONMENT FOR EXPRESS RACK PAYLOAD EQUIPMENT DESIGN

FREQUENCY	LEVEL
20 Hz	.010 g^2/Hz
20 - 80 Hz	+3.0 dB/oct
80 - 120 Hz	.04 g^2/Hz
120 - 2000 Hz	-4.0 dB/oct
2000 Hz	.00095 g^2/Hz
Composite	3.5 g_{rms}
Legend: grms-gravity (g), root means square oct=octave	

Criteria is the same for all directions (X, Y, Z).

TABLE 4-IV HIGH FREQUENCY RANDOM VIBRATION ENVIRONMENT FOR INTEGRATED ISIS DRAWERS

LOCATION	FREQUENCY	LEVEL
Input to rack-mounted equipment	20 Hz	0.0050 g^2/Hz
	20 - 70 Hz	+5.0 dB/oct
	70 - 200 Hz	0.040 g^2/Hz
	200 - 2000 Hz	-3.9 dB/oct
	2000 Hz	0.0020 g^2/Hz
	Composite	4.4 g_{rms}
Legend: grms=gravity (g), root means square oct-octave		

TABLE 4-V RANDOM VIBRATION CRITERIA FOR INTERNAL ISIS DRAWER MOUNTED COMPONENTS

FREQUENCY (HZ)	LEVEL
20	0.0050 g^2/Hz
20 - 70	+5.0 dB/oct
70 - 200	0.040 g^2/Hz
200 - 2000	-3.9 dB/oct
2000	0.002 g^2/Hz
Composite	4.4 g_{rms}

Criteria is the same for all directions (X, Y, Z).

4.3.2 Random Vibration - Middeck

The random vibration environments applicable to components mounted in the middeck during launch and ascent are as follows:

20 - 150 Hz	+6.00 dB/octave
150 - 1000 Hz	0.03 g^2/Hz
1000 - 2000 Hz	-6.00 dB/octave

Composite = 6.5 g(rms)

Environment exposure duration = 7.2 sec per flight in each of Xo, Yo, Zo axes.

The exposure duration of 7.2 sec per flight does not include a fatigue scatter factor. A fatigue scatter factor appropriate for the materials and method of construction is required and shall be not less than 4.0.

All payload equipment to be flown in the Shuttle middeck shall be shown to have positive margins of safety with the specified loads.

4.4 EXPRESS RACK MDL LOCATION INTERFACE LOADS

4.4.1 Single MDL Location Interface Loads

The weight-to-CG relationship for payloads attached to the EXPRESS Rack baseplate at a single MDL location shall conform to Table 4-VI.

TABLE 4-VI MDL OR MDL REPLACEMENT MAXIMUM MASS AND CG FOR MIDDECK, EXPRESS RACK, AND TRANSPORTATION RACK[6]

MDL CG (x in)	SINGLE MDL lb @ 3 in RADIUS				DOUBLE MDL lb @ 3 in RADIU				QUAD MDL lb @ 3 in RADIUS
	EXPRESS[3]	MIDDECK[4, 5]			EXPRESS[3]	MIDDECK[4, 5]			
		X, 0, 0	(X, ±3, 0)	(X, 0 ±3)		X, 0, 0	(X, ±3, 0)	(X, 0 ±3)	EXPRESS[7]
14	51	51	37	51	100	120	88	87	198
13	55	55	40	55	107	120	94	94	211
12	60	59	44	59	116	120	102	101	228
11	65	65	48	65	127	120	112	110	251
10	72	69	52	69	140	120	120	120	276

NOTES:

1. X_{CG} is measured from the backplate mounting surface of the payload either for the middeck or the EXPRESS Rack.
2. "Radius" applies to Y_{CG} and Z_{CG} locations.
3. This includes the EXPRESS transportation rack and the flight racks.
4. 14 in X_{CG} is maximum.
5. Middeck limitations are for reference only and include CG at center of plate ±3 in Y_{CG} and ±3 in Z_{CG}.
6. These are for launch/landing (i.e., transportation). Once on-orbit these restrictions do not apply.
7. Quad locker launches in the EXPRESS transportation rack only.

4.4.2 Double MDL Location Interface Loads

The weight-to-CG relationship for payloads attached to the EXPRESS Rack baseplate at a double MDL location shall conform to Table 4-VI.

4.4.3 Quad MDL Location Interface Loads

The weight-to-CG relationship for payloads attached to the EXPRESS transportation rack baseplate at a quad MDL location shall conform to Table 4-VI.

4.5 ON-ORBIT LOADS

4.5.1 Crew-Induced Loading

Payload equipment shall be designed to maintain positive margins of safety when exposed to the crew-induced loads defined in Table 4-VII.

TABLE 4-VII CREW-INDUCED LOADS

CREW SYSTEM OR STRUCTURE	TYPE OF LOAD	LOAD	DIRECTION OF LOAD
Levers, Handles, Operating Wheels, Controls	Push or pull concentrated on most extreme edge	50 lbf, limit (222.6 N)	Any direction
Small Knobs	Twist (Torsion)	11 ft-lbf, limit 14.9 N-M)	Either direction
Exposed Utility Lines (Gas, Fluid, and Vacuum)	Push or Pull	50 lbf (222.6 N)	Any direction
Subrack payload front panels and any other normally exposed equipment	Load distributed over an area 4 inches by 4 inches (0.11 ft^2) (0.01 m^2)	125 lbf, limit (556.4 N)	Any direction
Legend: ft = foot, feet; m = meter; N = Newton; lbf = pounds force			

4.5.2 On-Orbit Low Frequency Loads

Payload equipment shall be designed to maintain positive margins of safety when exposed to on-orbit loads of 0.2 g’s acting in any direction. It should be noted that this acceleration is a docking load.

4.6 EXPRESS RACK PAYLOAD STRUCTURAL DESIGN

4.6.1 Structural Design

EXPRESS Rack payload structural design and verification, including glass, window, and ceramic structures, shall be in accordance with the requirements specified in NSTS

1700.7 and ISS Addendum, NSTS 18798, and SSP 52005. The PD must ensure that positive margins of safety are maintained for all mission phases. An evaluation must be prepared by the PD to document all discrepancies between the design drawings and the as-built flight hardware. These discrepancies must be evaluated for impacts to the structural, mechanical, and dynamic analyses and/or tests. The PD shall update these analyses and re-perform these tests as required to reverify the structural integrity if the change warrants. The rack integrator must be contacted to discuss the impacts of these changes for any analyses updates or retesting.

4.6.2 Fracture Control

Payload structural components, including all pressure vessels, the failure of which would cause damage to the orbiter, damage to the ISS, or injury to personnel, shall be analyzed to preclude failures caused by propagation of pre-existing flaws. Fracture control documentation of critical structural components shall be processed by the PD in accordance with NSTS 1700.7 and its ISS Addendum, NSTS 13830, NSTS 18798 (including JSC Letter TA94-057, "Modified Fracture Control Criteria and Guidelines for Payloads"), NASA-STD-5003, and SSP 52005 during the payload safety review process.

4.7 ACOUSTICS

Equipment and payloads mounted in the EXPRESS Rack must satisfy the acoustic requirements as defined in the following paragraphs.

4.7.1 Lift-Off and Ascent Acoustics

Payloads shall be designed to withstand the Sound Pressure Levels (SPL) specified in Table 4-VIII.

4.7.2 Payload-Generated Acoustic Noise

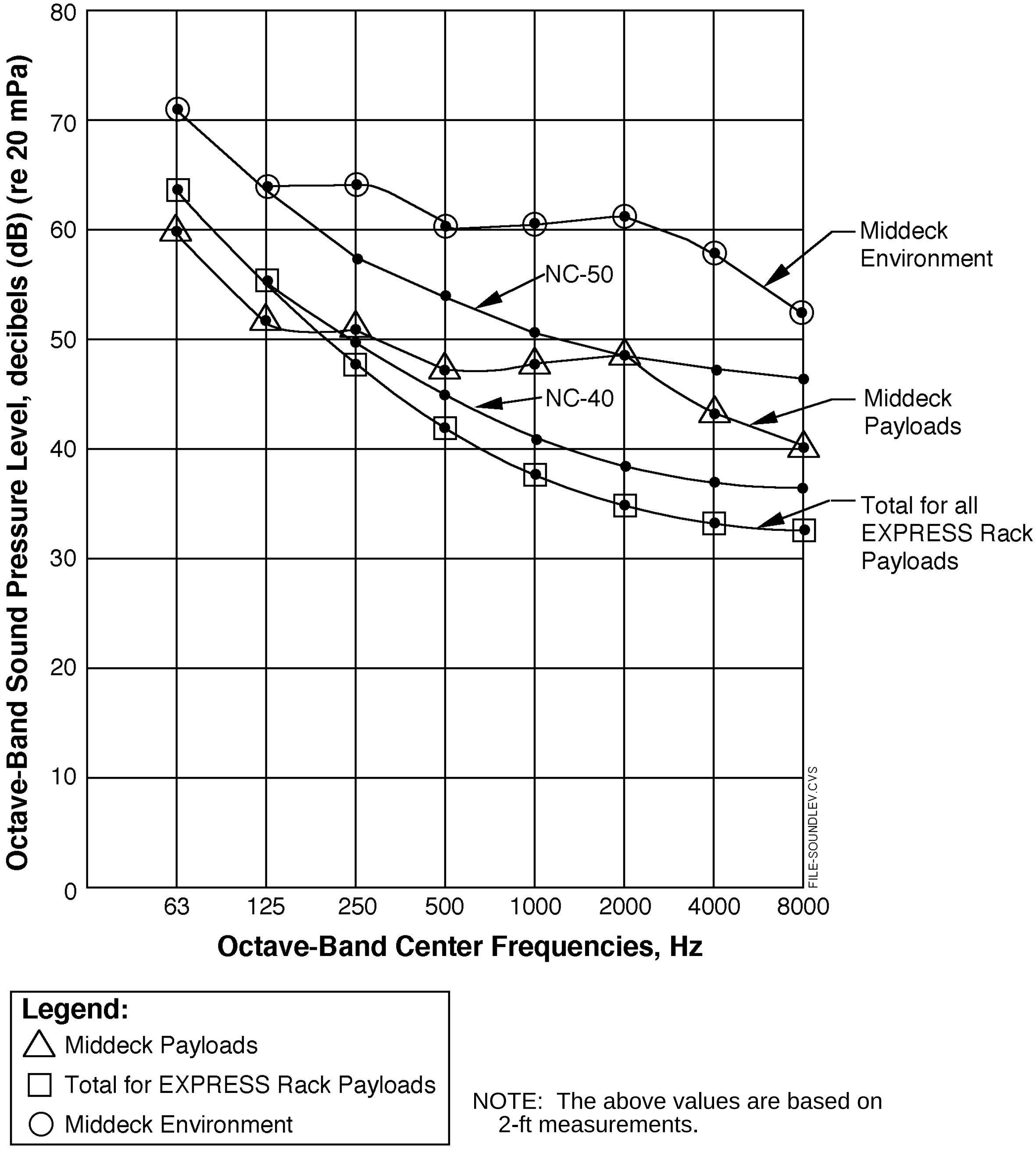
The total SPL of the integrated EXPRESS Rack (from all noise sources) will not exceed NC-40 (noise curve shown in Figure 4-2) in any octave band between 63 Hz and 8,000 Hz when measured at the loudest location 2 ft (0.6 m) inboard from the front of the payload rack. Figure 4-2 also shows the maximum continuous Sound Pressure Levels (SPL) in the Shuttle crew module for normal on-orbit operations resulting from all Shuttle installed equipment.

TABLE 4-VIII MIDDECK AND MPLM INTERNAL ACOUSTIC NOISE SPECTRA (LIFT OFF, ASCENT)[1]

1/3 octave band center frequency (HZ)	SOUND PRESSURE LEVEL (dB) ref. $2x10^{-5}$ N/m^2 (20 micropascals)			
	LIFT-OFF[2]		AERONOISE[3]	
	MIDDECK	MPLM	MIDDECK	MPLM
31.5	107	106.0	99	96.0
40.0	108	109.	100	99.5
50.0	109	111.5	100	102.0
63.0	109	114.0	100	105.0
80.0	108	116.0	100	108.0
100.0	107	117.5	100	110.0
125.0	106	118.5	100	112.0
160.0	105	119.0	99	113.5
200.0	104	119.0	99	115.0
250.0	103	118.0	99	116.0
315.0	102	117.5	98	116.5
400.0	101	115.5	98	114.5
500.0	100	112.5	97	111.0
630.0	99	109.5	97	107.5
800.0	98	107.0	96	104.5
1,000.0	97	103.0	95	101.5
1250.0	96	99.5	94	97.5
1,600.0	95	95.5	93	94.0
2,000.0	94	91.5	92	90.0
2,500.0	93	88.0	91	86.5
3,150.0	-	83.0	-	82.0
4,000.0	-	79.0	-	77.0
5,000.0	-	74.5	-	73.0
6,300.0	-	70.0	-	68.0
8,000.0	-	66.0	-	63.0
10,000.0	-	.060.0	-	57.5
Overall	11.7.5	127.5	111	123.5

NOTES:

1. Middeck data is shown for reference only as it is controlled in NSTS 21000-IDD-MDK.
2. Five seconds per mission (time per flight does not include a scatter factor).
3. Ten seconds per mission (time per flight does not include a scatter factor).



NOTE: The above values are based on 2-ft measurements.

FIGURE 4-2 NOISE CRITERIA CURVES (Sheet 1 of 2)

Octave-Band Sound Pressure Level Associated with Noise Curves

Noise Curve	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	O. A.	A-Wtd
• NC-40 (Integrated Rack)	64	56	50	45	41	39	38	37	-	-
• NC-50 (Integrated ISS)	71	64	58	54	51	49	48	47	-	-
• Middeck (1 Ft)[1]	64	56	55	51	52	53	48	44	66	58
• Middeck (2 Ft)[2]	60	52	51	47	48	49	49	40	62	54
• On-Orbit Middeck Environment	71	64	65	61	62	63	58	54	74	68
• Total for all ERPS	63	55	48	44	38	38	37	37	-	-

NOTES:

1. This is a 1-ft measurement requirement.
2. This is an extrapolated 2-ft measurement requirement.

FIGURE 4-2 NOISE CRITERIA CURVES (Sheet 2 of 2)

4.7.2.1 Acoustic Noise Definitions

4.7.2.1.1 Significant Noise Source

A significant noise source is any individual item of equipment or group of equipment items which collectively functions as an operating system that generates an A-weighted SPL equal to or in excess of 37 dBA, measured at a 0.6-m distance from the noisiest part of the equipment.

4.7.2.1.2 Continuous Noise Source

A significant noise source which exists for a cumulative total of eight hours or more in any 24-hr period is considered a continuous noise source.

4.7.2.1.3 Intermittent Noise Source

A significant noise source which exists for an accumulative total of less than eight hours in a 24-hr period is considered an intermittent noise source.

4.7.2.1.4 Acoustic Reference

All SPLs in decibels are referenced to 20 micropascals.

4.7.2.2 Acoustic Noise Limits

The acoustic limits that EXPRESS Rack payloads shall comply are provided in the Tables 4-X and 4-XI. These limits apply to measurements taken at the loudest location 0.6 m from each payload face, i.e., front, rear, top, bottom, left, and right. Actual flight equipment (each serialized unit) shall be used for flight acceptance testing, even though prototype or qualification units may have been tested earlier. These levels shall not be exceeded for the following conditions: when the equipment is operating in the loudest mode of operation that can occur on-orbit under nominal crew, or hardware operation circumstances, during payload setup operations, or during operations where doors/panels are opened or removed.

4.7.2.2.1 Continuous Noise Limits

An EXPRESS Rack payload which generates continuous noise levels shall not exceed the limits provided in Table 4-IX, column C, for all octave bands. These levels apply to a payload that is operated in the noisiest configuration or operating mode. Any independently operated equipment item, stowed within the rack or elsewhere, and deployed on-orbit for a separate function other than that of the rack system, shall individually comply with the acoustic requirements in Table 4-IX, column D.

4.7.2.2.2 Intermittent Noise Limits

If a payload is classified as an intermittent noise source (see paragraph 4.7.2.1.3), then the payload shall comply with the limits provided in Table 4-X.

The duration is the total time that the payload produces significant noise, i.e., equal to or greater than 37 dBA during a 24-hr time period. This duration is the governing factor in determining the allowable intermittent noise limits. Regardless of the number of separate sources and varying duration, this cumulative duration shall be used to determine the A-weighted SPL limit.

4.7.2.2.3 Continuous Noise Sources with Intermittent Noise Features

Continuous noise sources which exhibit intermittent acoustical characteristics shall meet both the continuous noise specification and the intermittent limits of paragraphs 4.7.2.2.1 and 4.7.2.2.2. The intermittent noise characteristics must be quantified in terms of:

A. When the intermittent sound occurs

TABLE 4-IX NOISE LIMITS FOR CONTINUOUS PAYLOADS

RACK NOISE LIMITS AT 0.6 METERS DISTANCE		MAXIMUM DESIGN LEVELS FOR ACTIVE HARDWARE ITEMS	
A	B	C	D
FREQUENCY BAND HZ	TOTAL RACK (dB)*	EXPRESS RACK PAYLOAD (DB)*	SINGLE ITEM OPERATED OUTSIDE OF THE RACK (DB)
63	64	58	59
125	56	50	52
250	50	42	45
500	45	38	39
1000	41	32	35
2000	39	32	33
4000	38	32	32
8000	37	31	31

*dB, re 20 μPa

TABLE 4-X INTERMITTENT NOISE LIMITS

MIDDECK REQUIREMENTS[1]		ISS REQUIREMENTS	
A-WEIGHTED SPL[2] (DBA)	MAXIMUM ALLOWABLE[2] DURATION[3]	A-WEIGHTED SPL (DBA)[4]	MAXIMUM ALLOWABLE[4] DURATION[3]
55-60	8 Hours	41	6 Hours
61-65	4 Hours	46	4 Hours
66-70	2 Hours	53	2 Hours
71-75	1 Hour	59	1 Hour
76-80	5 Minutes	70	5 Minutes
81-85	1 Minute	73	1 Minute
86 & Above	Not Allowed	80	Not Allowed

NOTES:

1. These are for middeck-located payloads and are for reference only.
2. A-weighted SPL, dB re 20 micropascals. Measured at 0.3-m distance from noisiest surface with equipment operating in the mode or condition that produces the maximum acoustic noise. Round dBA to nearest whole number.
3. Per 24-hr period.
4. A-weighted SPL, dB re 20 micropascals. Measured at 0.6-m distance from noisiest surface with equipment operating in the mode or condition that produces the maximum acoustic noise. Round dBA to nearest whole number.

TABLE 4-XI LIMIT LOAD FACTORS (g) FOR GROUND HANDLING, ROAD, AIR, AND BARGE OPERATIONS

TRANSPORTATION ENVIRONMENT	LIMIT LOAD FACTORS (G)			LOAD OCCURRENCE[1]
	LONGITUDINAL[2]	LATERAL	VERTICAL	
Truck/Road	±3.5	±2.0	-3.5 +1.5	I I
Barge/Water	±5.0	±2.5	-2.5	I
Dolly/Land	±1.0	±0.75	-2.0	I
Air Freight	±3.5	±3.5	-3.5	I
Forklifting	±1.0	±0.5	-2.0	S
Hoisting	0	0	-1.5	I

NOTES:

1. S = Loads occur simultaneously in the three directions.
   I = Loads occur independently in the three directions (except for gravity).
2. Longitudinal = Along axis of motion.

B. Duration

C. A projected mission timeline(s)

For items (A) and (B), maximum A-weighted SPL measured at a 0.6-m distance from the loudest part of the equipment. These data must be submitted to the ISS Acoustic Working Group.

4.7.2.3 Sound Power Readings on Payloads

The requirements which have been previously designated have been stated in terms of SPL. Payloads shall comply with these SPLs, but additional acoustic measurement information is required for mission planning and overall acoustic analysis purposes.

Sound power determinations shall be made of each individual payload. Sound power level measurements must be submitted as part of the verification data package submitted on acoustic specification compliance. Sound power determination measurements shall be performed in accordance with the appropriate standards as follows:

ANSI S1.4, Specification for Sound Level Meters Amendment S1.4A-1985 ASA 47 R (1994).

ANSI S1.11, Specification for Octave-Band and Fractional-Octave-Band Analog and Digital Filters; ASA 65-1986 R (1993).

ANSI S12.12-1992, Engineering Method for the Determination of Sound Power Levels of Noise Sources using Sound Intensity ASA 104.

ANSI S12.23-1989 (R1996), Method for the Designation of Sound Power Emitted by Machinery and Equipment

ANSI S12.31-1990 (R1996), Precision Methods for Determination of Sound Power Levels of Broad-band Noise Sources in Reverberation Rooms

ANSI S12.32-1990 (R1996), Precision Methods for the Determination of Sound Power Levels of Discrete Frequency and Narrow-band Noise Sources in Reverberation Rooms

ANSI S12.33-1990, Engineering Methods for the Determination of Sound Power Levels of Noise Sources in a Special Reverberation Test Room

ANSI S12.34-1988 (R1996), Engineering Methods for the Determination Sound Power Levels of Noise Sources for Essentially Free-Field Conditions Over a Reflecting Plane

ANSI-S12.35-1990 (R1996), Precision Methods for the Determination of Sound Power Levels of Noise Sources in Anechoic and Semi-anechoic Rooms.

ANSI-S12.36-1990, Survey Methods for the Determination of Sound Power Levels of Noise Sources

ISO 9614-2, Acoustics - Determination of Sound Power Levels of Noise Sources using Sound Intensity - Part 2: Measuring by Scanning (1996).

Equipment or facilities associated with performance of Sound Power Level Testing may be available from the ISS Program. Contact the applicable Payload Integration Manager (PIM) to determine availability, schedules, and locations.

4.7.2.4 Acoustic Test Plan for Payloads

An acoustic noise measurement test plan for the payload which defines the test configuration shall be generated. Configurations to be tested must be in compliance with the description of limits designated in paragraph 4.7.2.2 above. Test plans shall be submitted for approval to the ISS Acoustic Working Group, prior to testing.

4.8 DEPRESSURIZATION/REPRESSURIZATION REQUIREMENTS

Payload structures containing trapped volumes must maintain positive margins of safety per NSTS 1700.7 and ISS Addendum, NSTS 18798, and SSP 52005 when exposed to the worst-case depressurization/repressurization environments defined in the following paragraphs.

4.8.1 USL, APM, CAM, and JEM Maximum Depressurization/Repressurization Rates

The maximum depressurization rate for payloads located in the U.S. Lab (USL), Attached Pressurized Module (APM), Centrifuge Accommodation Module (CAM), and Japanese Experiment Module (JEM) is 7.64 psi/min (878 Pa/s).

The maximum repressurization rate for payloads located in the USL, APM, and JEM is 2 psi/min (230 Pa/s). The PD shall maintain positive margins of safety for these conditions using Figure 4-3 as a guide.

4.8.2 MPLM Maximum Depressurization/Repressurization Rate

The PD shall maintain positive margins of safety for the maximum depressurization rate of 7.75 psi/min (890 Pa/s) and the maximum repressurization rate of 6.96 psi/min (800 Pa/s) using Figure 4-3 as a guide.

4.8.3 Middeck Maximum Depressurization/Repressurization Rates

The maximum depressurization rate for payloads located in the middeck is 2.0 psi/min (nominal ops) and 9.0 psi/min (contingency - other than bailout).

The maximum repressurization rate for payloads located in the middeck is 2.0 psi/min (nominal ops) and 9.0 psi/min (contingency - other than bailout). The PD shall maintain positive margins of safety for these conditions.

4.8.4 Portable Fire Extinguisher (PFE) Discharge Rate

Payload equipment which has a PFE access port shall maintain positive margins of safety when exposed to the PFE discharge rate (i.e., pressurization) given in Figure 4-4

4.9 GROUND HANDLING ENVIRONMENTS

Flight hardware, which has the potential to create a flight safety hazard if damaged during ground transportation (including fracture-critical parts or components), must be analyzed for the applicable ground transportation and handling events in accordance with the following paragraphs.

4.9.1 Ground Handling Load Factors

Payloads which have the potential to create a flight safety hazard if damaged during handling and transportation (including fracture-critical parts or components) shall be analyzed in accordance with SSP 52005 using the transportation limit load factors defined in

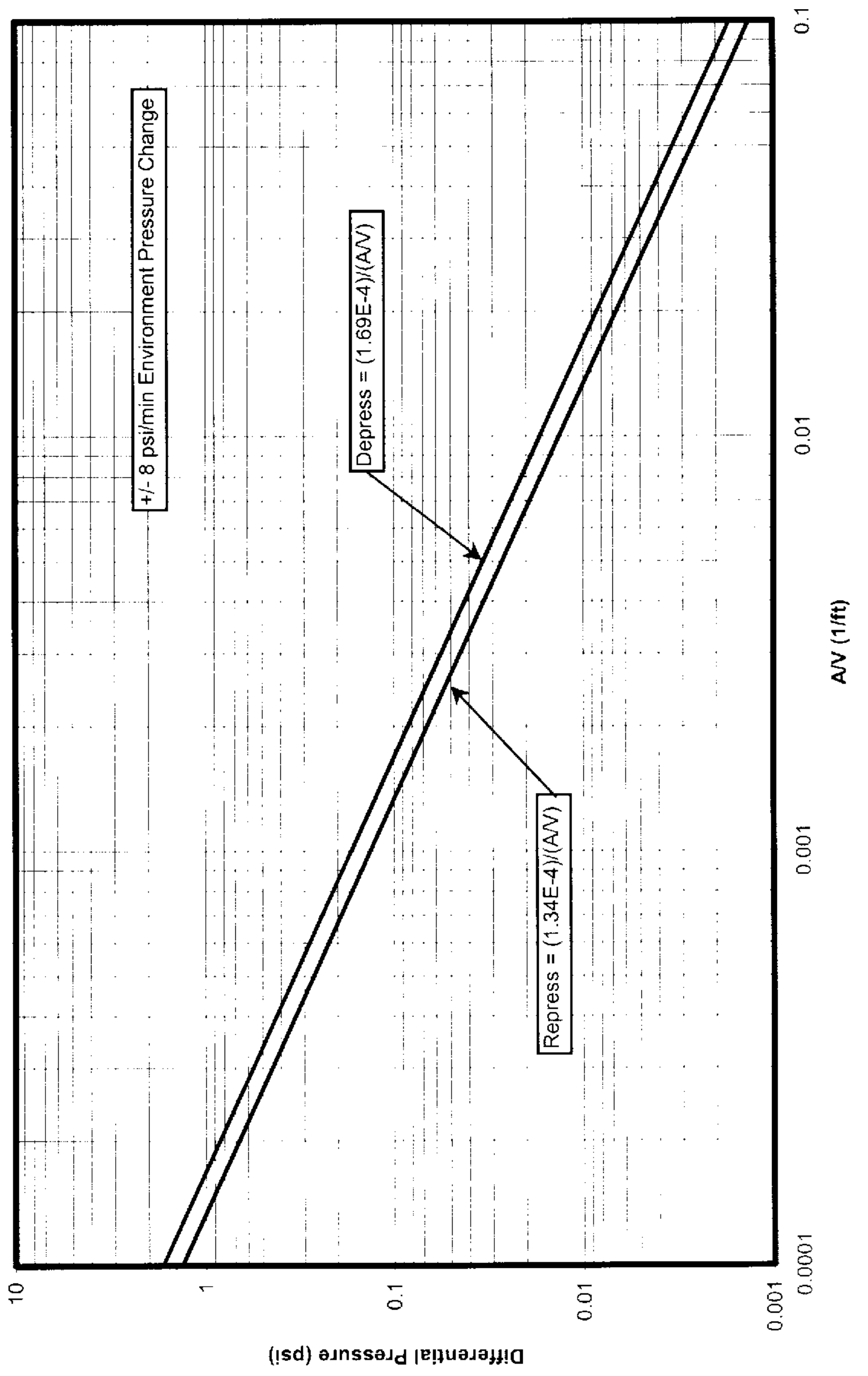


FIGURE 4-3 EXPRESS PROGRAM COMPONENT VENTING CHARACTERISTICS

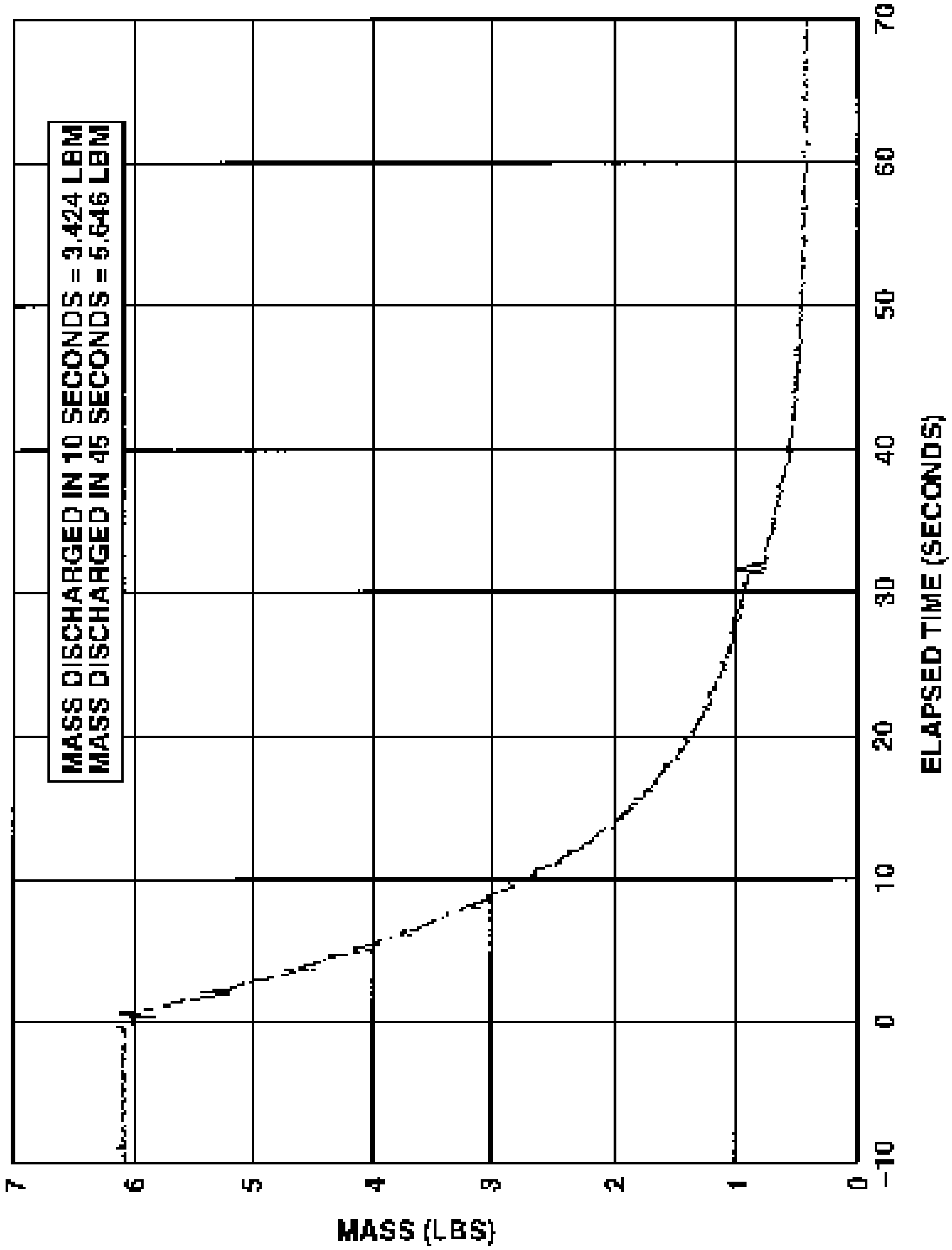


FIGURE 4-4 MANUAL FIRE SUPPRESSION SYSTEM PERFORMANCE CHARACTERISTICS AT THE RACK INTERFACE

Table 4-XI (for typical operations). These analyses shall evaluate the flight hardware in the shipping container configurations.

4.9.2 Ground Handling Shock Criteria

Payloads which have the potential to create a flight safety hazard if damaged during handling and transportation (including fracture-critical parts or components) shall be analyzed, in accordance with SSP 52005, for the drop requirements defined in FED-STD-101, Methods 5005.1, 5007.1, or 5008.1.

4.10 MICROGRAVITY DISTURBANCES

Microgravity requirements are defined to limit the disturbing effects of EXPRESS Rack subrack payloads on the microgravity environment of other payloads during microgravity mode (quiescent) periods. These requirements are separated into the quasi-steady category for frequencies below 0.01 Hz, the vibratory category for frequencies between 0.01 Hz and 300 Hz, and the transient category. For EXPRESS Rack subrack payloads, the interface points are the backplate MDL equivalent payloads, the ISIS drawer to ISIS liner interface for ISIS drawer payloads, and the connector panels for payload utility connections.

4.10.1 Quiescent Period Payload-Induced Quasi-Steady Accelerations

For frequencies below 0.01 Hz, EXPRESS Rack subrack payloads shall limit their quasi-static unbalanced translational average impulse to less than 10 lb-sec within any 10 to 500 second period.

EXPRESS rack subrack payloads which exceed a quasi-static unbalanced translational average impulse of 2.5 lb-sec within any 500 second period may require coordination of activities to prevent the integrated rack from exceeding the quasi-steady requirement of the integrated rack.

Note: Verification of compliance with the quasi-steady requirements must be by test or analysis.

4.10.2 Quiescent Period Payload-Induced Transient Accelerations

A. EXPRESS Rack subrack payloads shall limit the force applied to the EXPRESS Rack over any 10 second period to an impulse of no greater than 10 lb-sec (44.5 N-sec).

B. EXPRESS Rack subrack payloads shall limit their peak force applied to the EXPRESS Rack to less than 1000 lb (4448 N) for any duration.

Note: Verification of compliance with the transient requirements must be by test.

4.10.3 Quiescent Period Payload-Induced On-Orbit Vibration

EXPRESS Rack subrack payloads must determine compliance with the microgravity vibratory requirement by test or analysis. Test is the preferred method of verification. Analysis may be used only to characterize narrowband disturbances such as rotating imbalances or oscillating masses where a clear analytical solution is possible. Analysis must not be used for determination of wideband disturbances. If disturbance testing is performed at the subassembly level, then the dynamic effects of the payload structure must be accounted for analytically using finite element analysis or statistical energy analysis models.

A. Non-ARIS EXPRESS Rack Subrack Payloads

Between 0.01 and 300 Hz, non-ARIS EXPRESS Rack subrack payloads shall limit vibration so that the force limits of Figure 4-5 and Table 4-XIV are not exceeded.

B. ARIS EXPRESS Rack Subrack Payloads

Between 0.01 and 300 Hz, subrack payloads mounted in an EXPRESS Rack equipped with ARIS shall limit vibration so that the force limits of Figure 4-6 and Table 4-XV are not exceeded. These limits do no incorporate consideration of sway space and accelerometer saturation.

ARIS EXPRESS Rack subrack payload vibratory requirements associated with the considerations of sway space and accelerometer saturation of ARIS are **TBD#39**.

4.10.4 Angular Momentum Limits

This requirement applies only to payload disturbance forces and moments which generate pure internal angular momentum impulse greater than 100 ft-lb-sec (135 N-m-sec) or a maximum impulse greater than 1.1 lb-sec (5.2 N-sec) over any continuous period of nine minutes.

The following general requirements apply to the determination of applicability as stated above and to the evaluation of the ability of payloads to meet the limits of 4.10.4.1 and 4.10.4.2.

A. It is not necessary to consider transient or cyclic angular momentum changes that exceed limits over shorter intervals than the specified continuous duration if the cumulative angular momentum impulse limit is not exceeded by the end of the specified continuous duration.

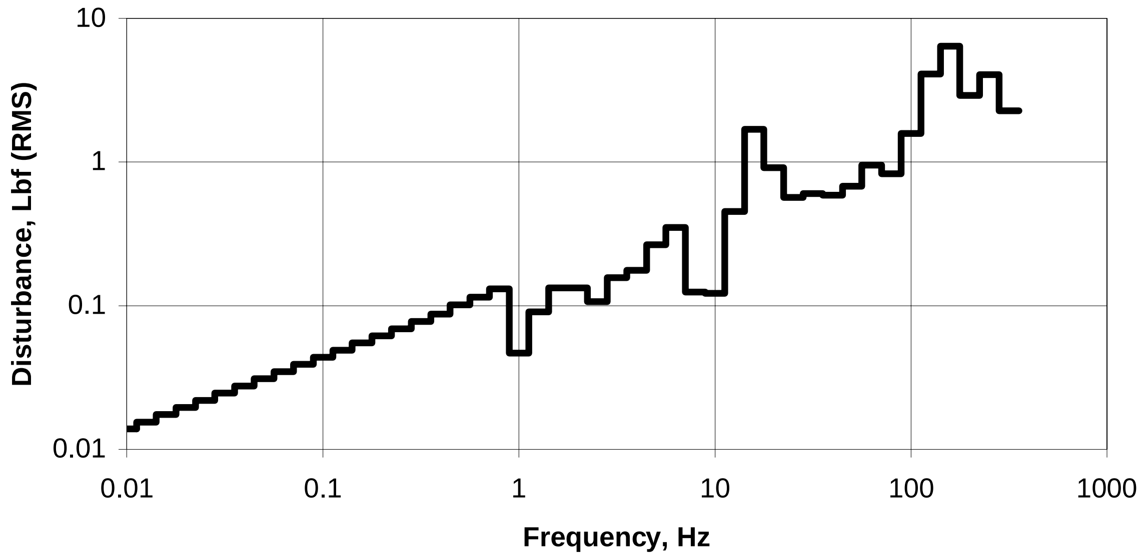


FIGURE 4-5 NON-ARIS EXPRESS RACK SUBRACK PAYLOAD VIBRATORY DISTURBANCES ALLOWABLE

B. The beginning and end times of continuous periods may be arranged in any order, as long as all periods of operation are covered in one or more continuous period. This permits start-ups followed by stopping actions within any nine minute window to be considered as cancelled angular impulse.

C. Shorter duration angular momentum impulse sources are covered by the microgravity transient and vibratory force limits, assuming standard ISPR attachment pint separation distances.

D. Payloads are not required to report angular momentum changes or forces resulting from the use of standard ISS resources such as the Vacuum Resource System (VRS) or Waste Gas System (WGS).

E. If the disturbance source produces translational forces, the disturbance torque due to the disturbance force will be calculated using the moment arm from the point of application of the force to the ISS assembly complete configuration center of mass. The location of the assembly complete configuration center of mass is specified in JSC-26557, ISS On-Orbit Assembly, Modeling and Mass Properties Databook.

F. If the disturbance source produces forces and moments, the disturbance moment due to the disturbance force will be added to the induced pure moments.

G. The locations of pure moments do not need to be reported.

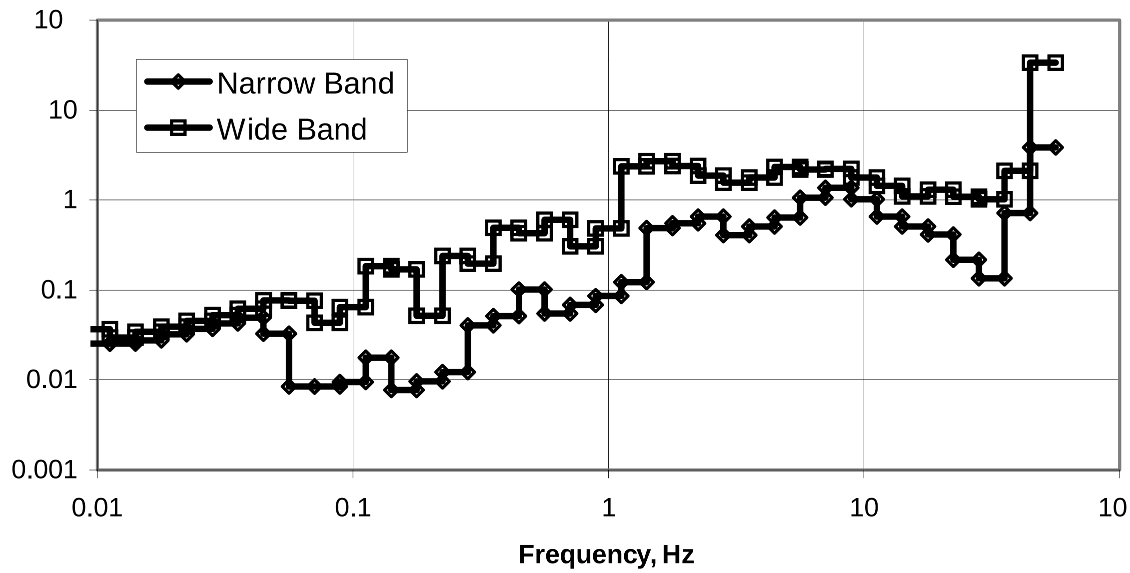


FIGURE 4-6 ARIS EXPRESS SUBRACK PAYLOAD ON-BOARD TO OFF-BOARD BASED FORCE ALLOWABLE

4.10.4.1 Limit Disturbance Induced ISS Attitude Rate

When the on-orbit Space Station is in the microgravity mode, any non-transitory disturbance induced on the on-orbit Space Station by an individual disturbance source of a payload shall have an angular momentum impulse of less than the per axis values shown in Table 4-XII during any continuous nine minute period. Over no interval of time of 10 seconds or less shall a payload angular momentum impulse exceed 250 ft-lb-s (340 N-m-s) and over no interval of time of two minutes or less shall a payload angular momentum impulse exceed 2900 ft-lb-s (3930 N-m-s). Angular momentum impulse due to gyroscopic moments (the cross-product of ISS orbital rate with payload angular momentum) may be excluded from these limits if the payload gyroscopic moment does not exceed 6 ft-lb (8.14 N-m).

TABLE 4-XII MAXIMUM ANGULAR MOMENTUM IMPULSE

AXIS	Hx	Hy	Hz
Ft-lb-sec	930	1277	2876
N-m-sec	1261	1732	3900

NOTE: Where Hz, Hy, and Hz are the x, y, and z components of the disturbance angular momentum relative to the coordinate system specified in SSP 30219, Figure 4.0-3.

4.10.4.2 Limit Disturbance Induced Control Moment Gyroscope (CMG) Momentum Usage

When the on-orbit Space Station is in the microgravity mode, any disturbance induced on the on-orbit Space Station by an individual disturbance source of a payload shall have an angular momentum impulse that produces an estimated CMG momentum magnitude less than 10,000 ft-lb-s (13,577 N-m-s) during any continuous 110 minute period when evaluated per expression in Table 4-XIII. Angular momentum impulse due to gyroscopic moments (the cross-product of ISS orbital rate with payload angular momentum) may be excluded from these limits if the payload gyroscopic moment does not exceed 6 ft-lb (8.14 N-m).

TABLE 4-XIII CMG MOMENTUM USAGE CALCULATION

ESTIMATED CMG MOMENTUM USAGE	
Ft-lb-sec	$SQRT((1.25 \times Hx + 1069)^2 + (1.25 \times Hy + 6885)^2 + (1.25 \times Hz + 779)^2) < 10{,}000$
N-m-sec	$SQRT((1.25 \times Hx +1449)^2 + (1.25 \times Hy + 9334)^2 + (1.25 \times Hz + 1056)^2) < 13{,}577$

NOTES:

1. Where Hx, Hy, and Hz are the x, y, and z components of the disturbance angular momentum relative to the coordinate system specified in SSP 30219, Figure 4.0-3.
2. Where 1069, 6885, and 779 ft-lb-sec (and 1449, 9334, and 1056 N-m-sec) and the x, y, and z components, respectively, of the CMG angular momentum allocation for environmental disturbances.

4.11 CONSTRAINTS FOR ARIS EXPRESS RACK ACTIVITY

Payloads located in ARIS racks shall not require physical access from the flight crew while the ARIS isolation system is active. This includes operation of switches, key pads, latches, doors, dials, or any other device that the flight crew must physically contact. The minimum continuous amount of time that the ARIS isolation system will be active is 30 days.

TABLE 4-XIV NON-ARIS EXPRESS SUBRACK PAYLOAD DISTURBANCE ALLOWABLE

OTO BAND BOUNDARY FREQUENCY Hz	PAYLOAD DISTURBANCE ALLOWABLE lbf	OTO BAND BOUNDARY FREQUENCY Hz	PAYLOAD DISTURBANCE ALLOWABLE lbf	OTO BAND BOUNDARY FREQUENCY Hz	PAYLOAD DISTURBANCE ALLOWABLE lbf	OTO BAND BOUNDARY FREQUENCY Hz	PAYLOAD DISTURBANCE ALLOWABLE lbf
0.00891	0.0138	0.1413	0.0487	2.239	0.1328	28.18	0.6014
0.01122	0.0138	0.1413	0.0550	2.239	0.1065	35.48	0.6014
0.01122	0.0154	0.1778	0.0550	2.818	0.1065	35.48	0.5856
0.01413	0.0154	0.1778	0.0617	2.818	0.1566	44.67	0.5856
0.01413	0.0174	0.2239	0.0617	3.548	0.1566	44.67	0.6764
0.01778	0.0174	0.2239	0.0690	3.548	0.1758	56.23	0.6764
0.01778	0.0195	0.2818	0.0690	4.467	0.1758	56.23	0.9488
0.02239	0.0195	0.2818	0.0775	4.467	0.2647	70.79	0.9488
0.02239	0.0218	0.3548	0.0872	5.623	0.2647	70.79	0.8287
0.02818	0.0218	0.4467	0.0872	5.623	0.3514	89.13	0.8287
0.02818	0.0245	0.4467	0.1010	7.079	0.3514	89.13	1.5812
0.03548	0.0245	0.5623	0.1010	7.079	0.1244	112.2	1.5812
0.03548	0.0275	0.5623	0.1149	8.913	0.1244	112.2	4.1082
0.04467	0.0275	0.7079	0.1149	8.913	0.1213	141.3	4.1082
0.04467	0.0310	0.7079	0.1309	11.22	0.1213	141.3	6.4103
0.05623	0.0310	0.8913	0.1309	11.22	0.4543	177.8	6.4103
0.05623	0.0347	0.8913	0.0467	14.13	0.4543	177.8	2.9032
0.07079	0.0347	1.122	0.0467	14.13	1.6898	223.9	2.9032
0.07079	0.0390	1.122	0.0903	17.78	1.6898	223.9	4.0825
0.08913	0.0390	1.413	0.0903	17.78	0.9128	281.8	4.0825
0.08913	0.0437	1.413	0.1324	22.39	0.9128	281.8	2.2695
0.1122	0.0437	1.778	0.1324	22.39	0.5690	354.8	2.2695
0.1122	0.0487	1.778	0.1328	28.18	0.5690		

TABLE 4-XV ARIS EXPRESS SUBRACK PAYLOAD ON-BOARD TO OFF-BOARD BASED FORCE ALLOWABLE

OTO BAND BOUNDARY FREQUENCY Hz	NARROW-BAND ALLOWABLE lbf	WIDEBAND ALLOWABLE lbf	OTO BAND BOUNDARY FREQUENCY Hz	NARROW-BAND ALLOWABLE lbf	WIDEBAND ALLOWABLE lbf	OTO BAND BOUNDARY FREQUENCY Hz	NARROWBAN ALLOWABLE lbf	WIDEBAND ALLOWABLE lbf
0.0089	0.0255	0.0365	0.1778	0.0097	0.0518	3.548	0.5068	1.781
0.0112	0.0255	0.0365	0.2239	0.0097	0.0518	4.467	0.5068	1.781
0.0112	0.0255	0.0298	0.2239	0.0122	0.2411	4.467	0.6446	2.341
0.0141	0.0255	0.0298	0.2818	0.0122	0.2411	5.623	0.6446	2.341
0.0141	0.0277	0.0343	0.2818	0.0405	0.1971	5.623	1.070	2.192
0.0178	0.0277	0.0343	0.3548	0.0405	0.1971	7.079	1.070	2.192
0.0178	0.0322	0.0393	0.3548	0.0511	0.4937	7.079	1.373	2.223
0.0224	0.0322	0.0393	0.4467	0.0511	0.4937	8.913	1.373	2.223
0.0224	0.0370	0.0452	0.4467	0.1018	0.4273	8.913	1.026	1.781
0.0282	0.0370	0.0452	0.5623	0.1018	0.4273	11.22	1.026	1.781
0.0282	0.0425	0.0526	0.5623	0.0549	0.6071	11.22	0.6576	1.441
0.0355	0.0425	0.0526	0.7079	0.0549	0.6071	14.13	0.6576	1.441
0.0355	0.0492	0.0623	0.7079	0.0688	0.3079	14.13	0.5073	1.093
0.0447	0.0492	0.0623	0.8913	0.0688	0.3079	17.78	0.5073	1.093
0.0447	0.0327	0.0766	0.8913	0.0854	0.4858	17.78	0.4155	1.310
0.0562	0.0327	0.0766	1.122	0.0854	0.4858	22.39	0.4155	1.310
0.0562	0.0085	0.0759	1.122	0.1219	2.373	22.39	0.2184	1.088
0.0708	0.0085	0.0759	1.413	0.1219	2.373	28.18	0.2184	1.088
0.0708	0.0085	0.0433	1.413	0.4895	2.698	28.18	0.1351	1.026
0.0891	0.0085	0.0433	1.778	0.4895	2.698	35.48	0.1351	1.026
0.0891	0.0095	0.0643	1.778	0.5538	2.400	35.48	0.7191	2.126
0.1122	0.0095	0.0643	2.239	0.5538	2.400	44.67	0.7191	2.126
0.1122	0.0177	0.1847	2.239	0.6527	1.870	44.67	3.855	34.03
0.1413	0.0177	0.1847	2.818	0.6527	1.870	56.23	3.855	34.03
0.1413	0.0077	0.1707	2.818	0.4069	1.563			
0.1778	0.0077	0.1707	3.548	0.4069	1.563			

SECTION 5, THERMAL/FLUIDS INTERFACE

5.1 GENERAL REQUIREMENTS

5.1.1 External Surface Touch Temperature

A. Payload metallic surface temperatures which are exposed to crewmember's bare skin contact shall be maintained between -18 °C (0 °F) and 49 °C (120 °F) unless intentional/incidental contact warrants provisions being applied as per paragraphs 5.1.1B and 5.1.1C. For non-metallic payload surfaces, the upper temperature limit for bare skin contact is higher than 120 °F and can be determined by using the method described in the NASA IVA Touch Temperature Safety interpretation letter, JSC MA2-95-048.

B. When payload metallic surfaces whose temperature exceeds 49 °C (120 °F), which are subject to continuous or incidental contact, are exposed to crewmember's bare skin contact, protective equipment shall be provided to the crew and warning labels shall be provided at the surface site. This also applies to the surfaces not normally exposed to the cabin in accordance with the NASA IVA Touch Temperature Safety interpretation letter, JSC MA2-95-048.

C. When payload surfaces below -18 °C (0 °F), which are subject to continuous or incidental contact, are exposed to crewmember's bare skin contact, protective equipment shall be provided to the crew and warning labels shall be provided at the surface site. This also applies to surfaces not normally exposed to the cabin in accordance with the NASA IVA Touch Temperature Safety interpretation letter, JSC MA2-95-048. PD hardware must still comply with the requirement stated in paragraph 5.1.2. If this condition does apply to the PD, the rack integrator should be contacted to discuss potential solutions.

5.1.2 Condensation Prevention

Payload surfaces shall be maintained above 60 °F (16 °C) (maximum dewpoint temperature) to prevent condensation.

5.1.2.1 Condensation Prevention (Refrigerators/Freezers)

A payload shall be designed to not cause condensation when exposed to a dewpoint of 4.5 to 15.6 °C (40 to 60 °F) and a relative humidity of 25% to 75% except when condensation is an intended operation of the payload when equipment which cools below the dewpoint (i.e., refrigerators, freezers, thermal electrical devices, etc.) are opened for insertion or removal of items, some condensation around the periphery of the opening may temporarily occur. This is acceptable and may be wiped off.

5.1.3 Loss of Cooling

Payloads using ISS EXPRESS Rack facility or payload-provided heat rejection systems (i.e., fans, pumps, water supply/flow, etc.) shall have the appropriate failure tolerance to prevent a hazard from occurring based on the type hazard which results from loss of cooling. The loss of cooling shall be considered the first failure in performing the hazard analysis if cooling is interrupted.

5.1.4 Pressure Relief/Vent Valve Sizing

Pressure relief devices, Pressure Relief Valves (PRV), and venting areas shall be set or sized such that the pressure differentials of captured volumes in sealed and semi-sealed enclosures shall not exceed the Maximum Design Pressure (MDP). The MDP is defined as the maximum pressure reached in a contained volume after consideration of any two credible failures (i.e., failure of the PRV, Heater Fail “ON,” etc.)

5.1.5 Pressurized Gas Systems

Pressurized gas systems with a total expanded gas volume exceeding 400 liters at standard conditions shall limit the gas flow after a single failure to less than 240 standard liters per minute (SLPM) after 400 liters at standard conditions has been released to the cabin air.

5.2 ISS LABORATORY (CABIN) ENVIRONMENTAL CONDITIONS

The environmental conditions for the ISS laboratories will vary as shown in Table 5-I and shall be used in the payload design and analyses.

5.3 PAYLOAD ELEMENT COOLING

5.3.1 Payload Heat Dissipation

Payload waste heat will be dissipated to cabin air (restricted capability), avionics air, and/or moderate temperature water loop. The primary method is the AAA loop or the water cooling loop. Payloads which operate during low pressure cabin environment periods must design cooling based on 10.2-psia (70.3-kPa) middeck pressure as shown in Table 5-I. EXPRESS Rack payloads located in the MPLM will not be powered for ascent or descent.

TABLE 5-I ENVIRONMENTAL CONDITIONS[3] (Sheet 1 of 3)

ENVIRONMENTAL CONDITION	VALUE
Atmospheric Conditions	
Pressure Extremes	0 to 104.8 kPa (0 to 15.2 psia)
ISS Cabin Pressure	15.2 psia (104.8 kPa) max. on orbit (Pressure Relief Valve Operation) 18.1 psia (124.8 kPa) max. (Ground Pressurization Test)
Middeck Cabin Pressures	Reduced cabin pressure 10.2 ± 0.5 psia (70.3 ± 3.4 kPa) (±0.2 psia (1.4 kPa) dynamic operating range, ±0.3 psia (±2.1 kpa) sensor bias error)
Middeck Cabin O_2 Concentration	25.9% at 14.7 ±0.2 psia 30% maximum at 10.2 psia
Contingency Hole In Middeck Cabin (payload required to be powered off)	32.0% At 8 psia
Nominal Operating Pressure	See Figure 5-1
Oxygen Partial Pressure	See Figure 5-1
Nitrogen Partial Pressure	See Figure 5-1
ISS Cabin Rate of Pressure Change	Reference Paragraph 4.8.1 of this document.
Dewpoint	4.4 to 15.6 °C (40 to 60 °F) (See Figure 5-1a)
Percent Relative Humidity	25 to 75 (See Figure 5-1a)
Carbon dioxide partial pressure during normal operations with 6 crewmembers plus animals	24-hr average exposure 5.3 mmHg[2] Peak exposure 7.6 mmHg
Carbon dioxide partial pressure during crew changeout with 11 crewmembers plus animals	24-hr average exposure 7.6 mmHg7 Peak exposure 10 mmHg
Cabin Air Temperature in USL, JEM, APM, and CAM	17 to 28 °C (63 to 82 °F)
Cabin Air Temperature in Node 1	17 to 31 °C (63 to 87 °F)
Temperature (Structure/Middeck)	120 °F max. (48.9 °C) (all mission phases)
Exhaust Temperature (air)	120 °F (48.9 °C) max.
Mean Radiant Temperature - Cabin - Adjacent Rack(s) - Adjacent Payload(s)	 65 to 86 °F (18.3 to 30 °C) 65 to 104 °F (18.3 to 40 °C) 65 to 122 °F (18.3 to 50 °C)
Air Velocity	0.051 to .203 m/s (10 to 40 ft/min)
Airborne Microbes	Less than 1,000 CFU/m^3
Atmosphere Particulate Level	Average less than 100,000 particles/ft^3 for particles less than 0.5 microns in size
MPLM Air Temperatures	Active Flights
Pre-launch	14 to 30 °C (57.2 to 86 °F)

TABLE 5-I ENVIRONMENTAL CONDITIONS[3] (Sheet 2 of 3)

ENVIRONMENTAL CONDITION	VALUE
Launch/Ascent	20 to 30 °C (68 to 86 °F)
On-orbit (Cargo Bay + Deployment)	16 to 46 °C (60.8 to 114.8 °F)
On-orbit (On-Station)	16 to 43 °C (60.8 to 109.4 °F)
On-orbit (Retrieval + Cargo Bay)	11 to 45 °C (63 to 113 °F)
Descent/Landing	10 to 42 °C (50 to 107.6 °F)
Post-Landing	10 to 42 °C (50 to 107.6 °F)
Ferry Flight	15.5 to 30 °C (59.9 to 86 °F)
	Passive Flights
Pre-launch	15 to 24 °C (59 to 75.2 °F)
Launch/Ascent	14 to 24 °C (57.2 to 75.2 °F)
On-orbit (Cargo Bay + Deployment)	24 to 44 °C (75.2 to 111.2 °F)
On-orbit (On-Station)	23 to 45 °C (73.4 to 113 °F)
On-orbit (Retrieval + Cargo Bay)	17 to 44 °C (62.6 to 111.2 °F)
Descent/Landing	13 to 43 °C (55.4 to 109.4 °F)
Post-Landing	13 to 43 °C (55.4 to 109.4 °F)
Ferry Flight	15.5 to 30 °C (59.9 to 86 °F)
MPLM Maximum Dewpoint Temperatures	Active Flights
Pre-launch	-34.4 to -17.8 °C (-30 to 0 °F)
Launch/Ascent	-34.4 to -17.8 °C (-30 to 0 °F)
On-orbit (Cargo Bay + Deployment)	-34.4 to -17.8 °C (-30 to 0 °F)
On-orbit (On-Station)	15.5 °C (60 °F)
On-orbit (Retrieval + Cargo Bay)	-34.4 to -17.8 °C (-30 to 0 °F)
Descent/Landing	-34.4 to -17.8 °C (-30 to 0 °F)
Post-Landing	-34.4 to -17.8 °C (-30 to 0 °F)
Ferry Flight	15.5 °C (60 °F)
	Passive Flights
Pre-launch	-34.4 to -17.8 °C (-30 to 0 °F)
Launch/Ascent	-34.4 to -17.8 °C (-30 to 0 °F)
On-orbit (Cargo Bay + Deployment)	-34.4 to -17.8 °C (-30 to 0 °F)
On-orbit (On-Station)	15.5 °C (60 °F)
On-orbit (Retrieval + Cargo Bay)	-34.4 to -17.8 °C (-30 to 0 °F)
Descent/Landing	-34.4 to -17.8 °C (-30 to 0 °F)
Post-Landing	-34.4 to -17.8 °C (-30 to 0 °F)
Ferry Flight	15.5 °C (60 °F)
Thermal Conditions	
USL Module Wall Temperature	13 to 43 °C (55 to 109 °F)
JEM Module Wall Temperature	13 to 45 °C (55 to 113 °F)

TABLE 5-I ENVIRONMENTAL CONDITIONS[3] (Sheet 3 of 3)

ENVIRONMENTAL CONDITION	VALUE
APM Module Wall Temperature	13 to 43 °C (55 to 109 °F)
CAM Module Wall Temperature	13 to 43 °C (55 to 109 °F)
Other Integrated Payload Racks	Front surface less than 37 °C (98.6 °F)

NOTES:

1. All payload hardware located in the ISS laboratories shall be certified safe for the above environments.
2. If required, the ISS cabin CO_2 partial pressure can be reduced to less than 2.8 mmHg. Additional resources are required to operate the second United States Orbital Segment (USOS) CO_2 removal assembly.
3. Applies to all ISS laboratories (USL, JEM, APM, CAM, etc.).
4. If a PD desires to maximize its opportunities for manifesting, the worst-case of the modules should be enveloped by the payload design.

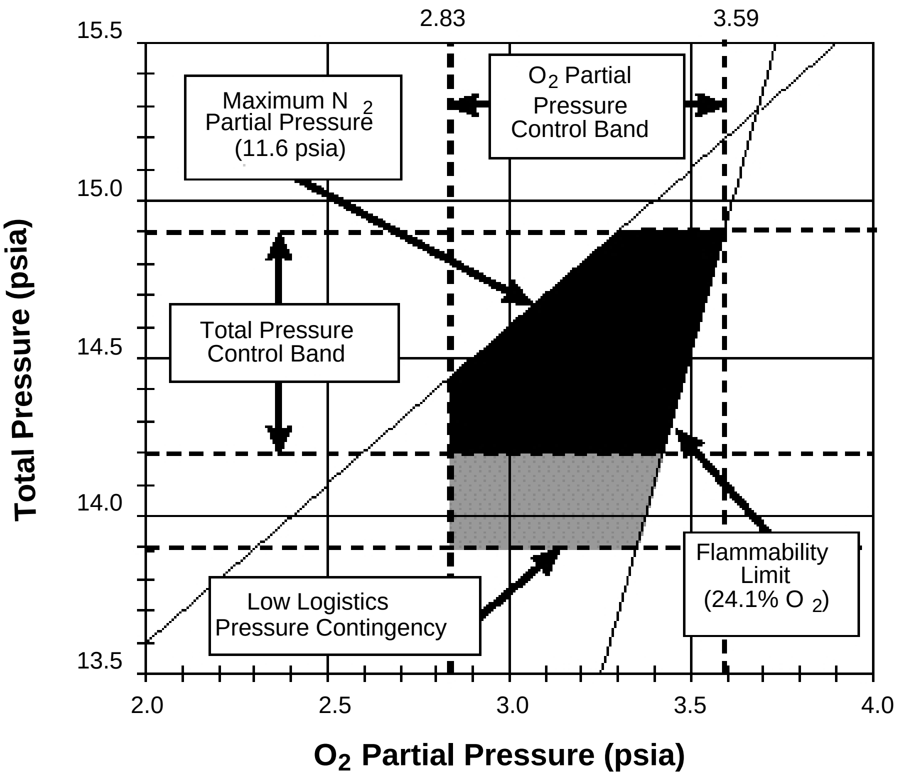


FIGURE 5-1 OPERATING LIMITS OF THE ISS ATMOSPHERIC TOTAL PRESSURE, AND NITROGEN AND OXYGEN PARTIAL PRESSURE

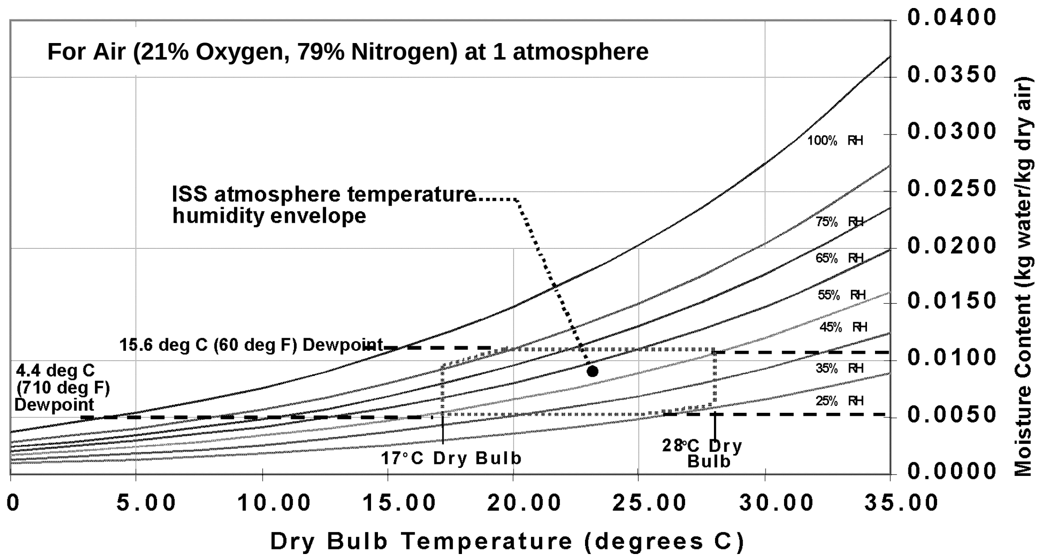


FIGURE 5-1A ISS TEMPERATURE/HUMIDITY ENVELOPE

5.3.1.1 Passive Cooling

Note: For reference, the heat load for a standard (i.e., middeck) stowage locker is limited to 60 W in the Shuttle middeck. Real-time constraints will be used to determine payload operating times and allowable cabin heat dissipation. The cabin dissipation value is for the entire EXPRESS Rack, may be suballocated and includes radiated, convected and heat exhausted via a PD fan to the cabin.

5.3.1.1.1 Payload Front Surface Temperature

The EXPRESS Rack payload shall be designed not to exceed an average front surface temperature limit of 37 °C (98.6 °F) with a maximum temperature limit not to exceed 49 ºC (120 ºF).

5.3.1.1.2 Cabin Air Heat Leak

The sensible heat leak to the cabin air from the EXPRESS Rack payload either alone or together with the other EXPRESS Rack payloads simultaneously active shall not exceed the values in Table 5-VIII.

5.3.1.1.3 Convective Heat Transfer Coefficient

The ISS design value for the convective heat transfer coefficient from the payload enclosure to the cabin environment is 0.20 Btu/hr °F ft^2 for 14.7 psia or 0.17 Btu/hr °F ft^2 for 10.2-psia cabin pressure. These values shall be used in thermal analysis/testing.

5.3.1.2 Active Cabin Air Cooling/Heating Interface

When a payload provides an air circulation fan which internally circulates the air and discharges to the cabin, the maximum air outlet temperature shall not exceed 120 °F (48.9 °C).

Note: For the middeck, the maximum exhaust temperature is 120 °F. It should also be noted that UF-3 and subsequent USL flights payloads will be required to exchange air with the EXPRESS Rack AAA and/or water cooling system and not the cabin air. This will also alleviate any fire detection/suppression issues. The cabin air will only cool the small amount of heat radiated and convected into the cabin by powered equipment.

5.3.1.2.1 Particulate(s) and Filters/Debris Traps

The payload cabin air cooling design will consider the possible ingestion of contamination from the cabin (e.g., 1.0 gram of lint-like material and/or 1.0 in^2 material blockage in 16 days in the middeck); otherwise, the PD must provide protection from this contamination. The PD cooling system shall not contribute to the contamination of the cabin air or the avionics air loop.

Depending on the amount of air exchange between the cabin air and the “semi-closed” EXPRESS Rack avionics air, filters may be required on payloads and periodic filter cleaning may be required.

Note: The orbiter avionics filters are designed to provide a flow area of 1 to 5 lbm^2/hr using 50 by 250 micron pleated filter.

5.3.1.3 Avionics Air Cooling

In the EXPRESS Rack the conditioned air is referred to as “avionics air.” This conditioned air is provided to the payload equipment for heat rejection.

5.3.1.3.1 Physical Interface

5.3.1.3.1.1 MDLs

The avionics air cooling for EXPRESS Rack-mounted payloads in MDL positions will be provided to the backplate as shown in Figure 3-5. The payload physical interface must be compatible with this interface. Note: The avionics supply loop air is not physically connected to the payload inlet, but it is the local area as shown in Figure 3-5.

5.3.1.3.1.2 ISIS Drawers

ISIS avionics air is not ducted to the drawer air inlets. Figure 3-19 illustrates the location of the ISIS drawer air inlets and outlets. Drawer payloads intake air from the rear open volume of the EXPRESS Rack. The drawer supply air temperature will be driven by the specific payload complement and, under worst-case conditions, the air temperature could reach 95 °F. Drawer payloads should be limited to water cooled, passively cooled stowage, or hardware compatible with elevated temperatures.

5.3.1.3.1.3 Fans

The payload shall provide its own circulation fan for internal air circulation for both the MDL interface and the ISIS drawer interface.

5.3.1.3.1.4 Sealing Surfaces

ISIS drawers shall provide a seal (silicone foam or equivalent) on the rear surface of the front panel and the MDLs on the rear surface to minimize air exchange and to increase acoustic attenuation of the AAA. Note: Rear-breathing payloads being transported to/from the ISS in the middeck not only will utilize the seal on the VPMP but also must provide a seal on the rear surface of the equipment item for mounting in the EXPRESS Rack.

5.3.1.3.1.5 Maximum Air Leakage Across Payload Mounting Interface

The maximum allowable air leakage at each MDL or ISIS drawer interface shall be five standard cubic inches per minute (scim) at 0.5 inches of water at ambient temperature.

5.3.1.3.2 Air Supply Temperature

The payload hardware shall be compatible with an air temperature within the range of 65 to 85 ºF (18.3 to 29.4 ºC) via the AAA (temperature is dependent on the subrack payloads operating). Note: Internal temperature sensors in the payload hardware (even though not required) will enhance the determination of the actual/real-time temperature due to air mixing and configuration changes in the EXPRESS Rack.

Also note that PD hardware items which use recirculation air will see temperatures at or near the PD hardware item's exhaust temperature.

5.3.1.3.3 Air Flow Rate

5.3.1.3.3.1 MDLs

The payload hardware shall be compatible with a flow rate for a single MDL position of 15 ±3 cfm. Payloads with air flow requirements over 15 cfm must draw air from the rear area of the rack. The average air inlet temperature will be a combination of 15 cfm (nominal) of air from the AAA and the remaining air at a higher temperature driven by the specific payload complement cooling and exhaust back to the rack environment as determined by the payload design. The air inlet temperature is driven by the specific subrack payload complement.

5.3.1.3.3.2 ISIS Drawers

ISIS avionics air is not ducted to the drawer air inlets. Figure 3-19 illustrates the location of the ISIS drawer air inlets and outlets. Drawer payloads intake air from the rear open volume of the EXPRESS Rack. The drawer supply air temperature is driven by the specific subrack payload complement. Under worst case conditions, the PD design-to air temperature shall be less than or equal to 95 °F.

Note: Due to the warmer air temperatures predicted in the ISIS drawer locations, PDs should limit the use of ISIS drawers to water cooled items, passively cooled stowage items or PD hardware compatible with these temperatures.

5.3.1.3.4 Air Return Temperature

The maximum return temperature (i.e., exhaust air) from the payload to the EXPRESS Rack avionics air loop shall not exceed 120 °F (48.9 °C) for either an ISIS drawer or MDL-type payload.

5.3.1.3.5 Payload Inlet Debris Traps

Payloads interfacing to the EXPRESS Rack avionics air system shall include debris traps at the payload inlet of ≤280 μ size. This debris trap shall have provisions for cleaning.

5.3.1.3.6 Maximum Allowable Heat Dissipation

The maximum allowable heat dissipation for the integrated EXPRESS Rack avionics air loop is limited to 1,200 W for all EXPRESS Rack payloads and will be suballocated to each payload by the ERO.

5.3.1.3.7 Payload Limitations on Heat Conducted to Structure

All payload internal temperature requirements shall be met by heat rejection to only the cooling water loops and avionics air cooling circulated through the payload. Payloads do not need to be designed to be thermally isolated from the rack structure. Payloads shall not design to account for conducting payload heat to the rack structure.

5.3.1.4 Middeck Ducted Air Cooling

The ducted cooling for middeck-mounted payloads in avionics bays 1, 2, and 3A will be provided via a soft interface. A schematic for these ducted payloads is shown in Figure 5-2. Payloads shall be required to provide their own circulation fan as shown in Figure 5-3 for a double locker payload. The payload hot exhaust air will be circulated into the soft interface air plenum where the orbiter outlet duct will be attached. The orbiter outlet duct will draw in the payload hot exhaust air in order to minimize payload air recirculation. The maximum middeck ducted air cooling capability will be 1,775 W from avionics bays 1, 2, and 3A. Ducted air cooling capability will only be available on OV-103 and subs as shown in Table 5-II. Total ducted cooling air flow available to all manifested payload electronics located in the middeck will be dependent on the air flow distribution in each of the avionics bays.

If payload air flow is greater than the orbiter-provided air flow, then payload air flow recirculation will occur. Inlet air temperature to the payload will be dependent upon the payload flow recirculation and payload heat dissipation. Tables 5-III and 5-IV show the effect of recirculation on the inlet air temperatures for orbiter flow rates of 18 cfm and 36 cfm, respectively. The delta T across the payload may be calculated from Tout minus payload inlet temperature.

5.3.1.4.1 Bay 1 Ducted Air Cooling Capability

Total Orbiter bay 1 air cooling capability is as shown in Table 5-III.

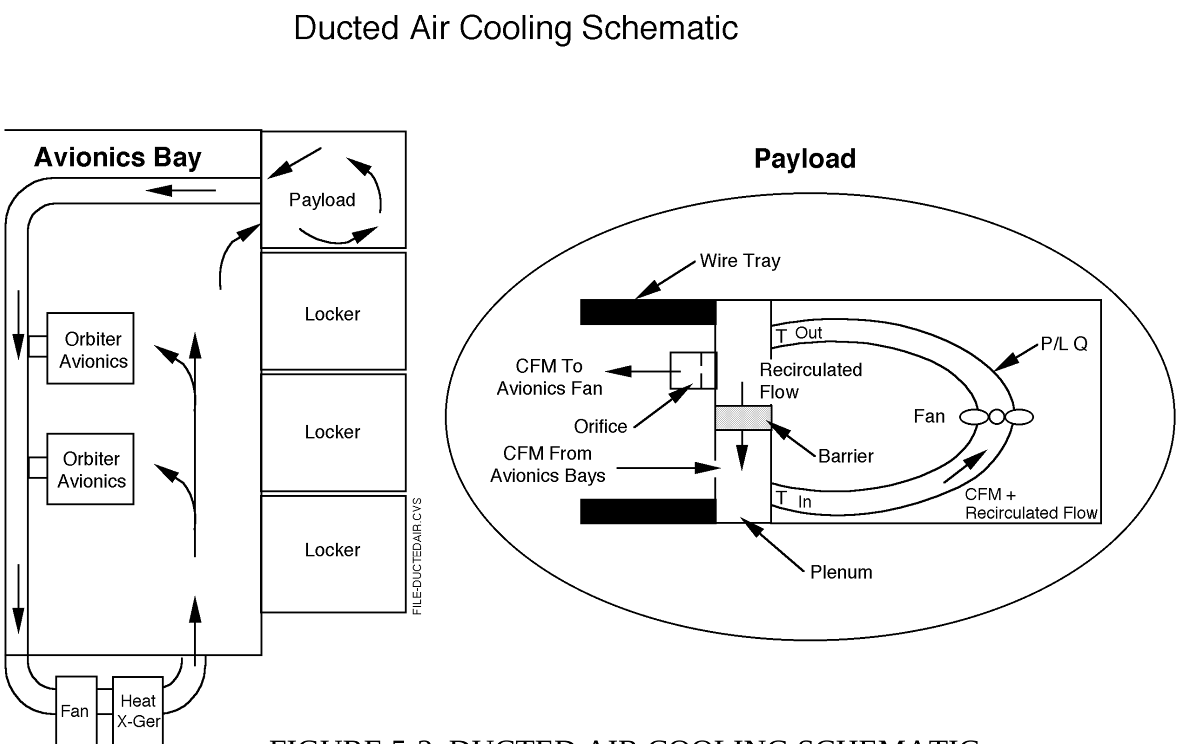


FIGURE 5-2 DUCTED AIR COOLING SCHEMATIC

5.3.1.4.1.1 Bay 1 Standard Air Flow Capability

The standard orbiter air flow rate capability for an individual middeck payload will be 18 or 36 cfm. The amount of air available will be dependent upon the total orbiter payload manifest.

If payload air flow is greater than the orbiter-provided air flow, then payload air flow recirculation will occur. Inlet air temperature to the payload will be dependent upon the payload flow recirculation and payload heat dissipation. The effect of recirculation on the inlet air temperatures for orbiter flow rates will be shown in NSTS 21000-IDD-MDK. The delta T across the payload may be calculated from T_{out} minus payload inlet temperature.

5.3.1.4.1.2 Bay 2 Ducted Air Cooling Capability

Total Orbiter bay 2 air cooling capability is as shown in Table 5-IV.

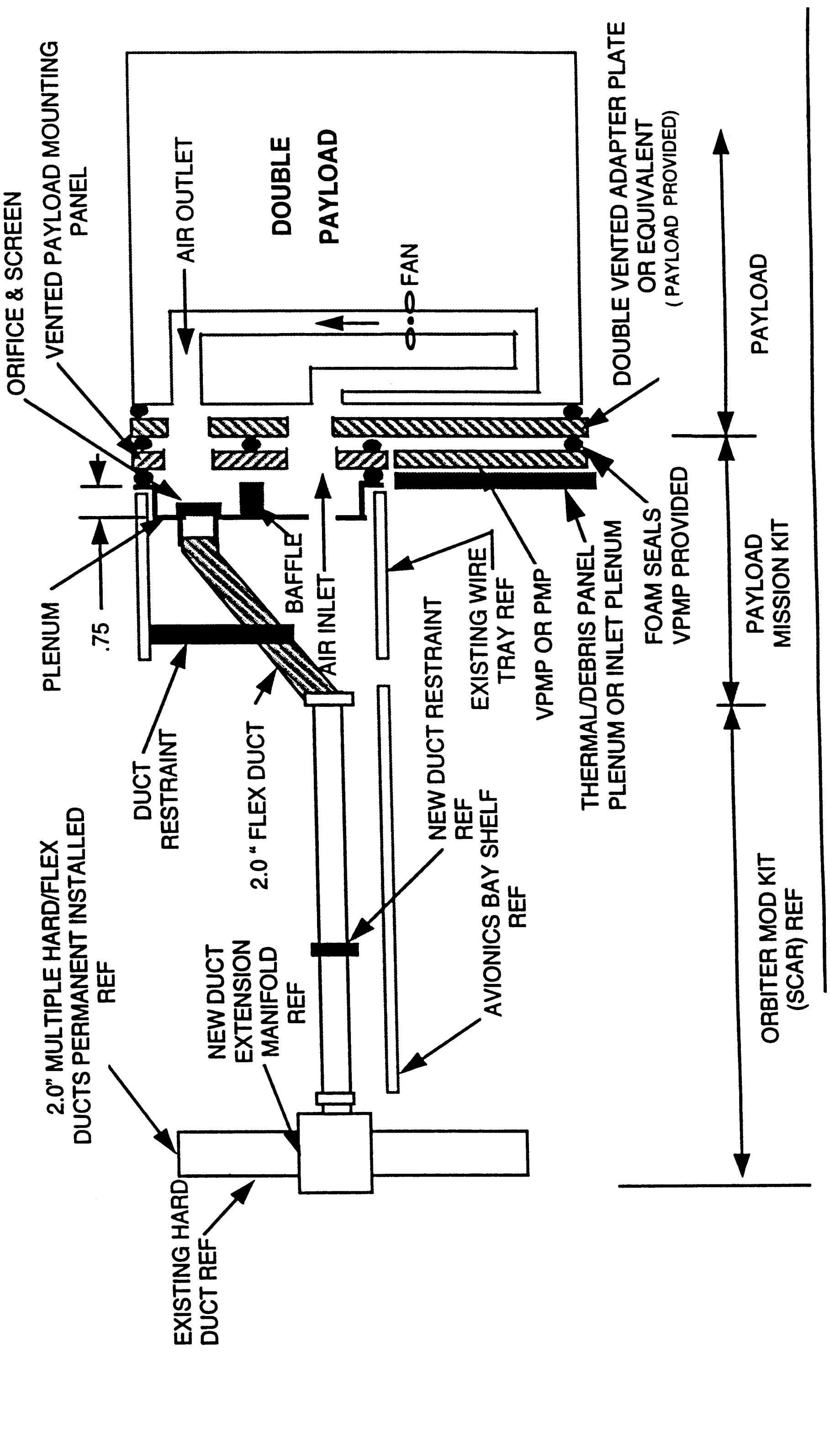


FIGURE 5-3 PAYLOAD-TO-COOLING SYSTEM INTERFACE TOP INLET, TOP OUTLET DOUBLE PAYLOAD-SYSTEM SCHEMATIC (SHOWN FOR REFERENCE ONLY)

TABLE 5-II MAXIMUM DUCTED (TOTAL BAY) AIR COOLING CAPABILITY AVAILABILITY (1, 2)

VEHICLE/YEAR EFFECTIVITY	BAY 1	BAY 2	BAY 3A
OV - 102	N/A	N/A	N/A
OV - 103 12/00	450 W/40 cfm	325 W/30 cfm	1000 W/180 cfm
OV - 104 1/01	450 W/40 cfm	325 W/30 cfm	1000 W/180 cfm
OV - 105 11/01	450 W/40 cfm	325 W/30 cfm	1000 W/180 cfm

NOTES:

1. Cooling capability identified at 14.7-psia conditions only.
2. Maximum capability assumes no active air cooling required for orbiter Tactical Aircraft Navigation (TACAN) support.
3. Table shown for reference only.

TABLE 5-III MAXIMUM BAY 1 DUCTED AIR COOLING CAPABILITY

CABIN PRESSURE (psia)	COOLING CAPABILITY (W) (1)	FLOW RATE (cfm)	AVG DELTA T ACROSS P/L (°F) (2)	INLET TEMPERATURE (°F) (3)
14.7	450	40	35	65 - 80 (Normal Operations) 95 Max Peak (Ascent/Descent) (4)
10.2	315	40	35	65 - 80 (Normal Operations)

NOTES:

1. Maximum capability assumes no active air cooling required for TACAN support. For current (March 1996) OV-105 orbiter configuration, reduction of 150 W required for orbiter TACA support.
2. Average payload delta T shown for reference.
3. Inlet temperatures of 80 °F assumes no heat transfer from payload to orbiter attach structure and no payload flow recirculation.
4. Duration and transient profile per Figure 5-4.
5. Table shown for reference only.

TABLE 5-IV MAXIMUM BAY 2 DUCTED AIR COOLING CAPABILITY

CABIN PRESSURE (psia)	COOLING CAPABILITY (W) (1)	FLOW RATE (cfm)	AVG DELTA T ACROSS P/L (°F) (2)	INLET TEMPERATURE (°F) (3)
14.7	325	30	35	65 - 80 (Normal Operations) 95 Max Peak (Ascent/Descent) (4)
10.2	225	30	35	65 - 80 (Normal Operations)

NOTES:

1. Maximum capability assumes no active air cooling required for orbiter TACAN support. For current (March 1996) OV-103 and OV-104 orbiter configurations, reduction of 150 W required for orbiter TACAN support.
2. Average payload delta T shown for reference.
3. Inlet temperatures of 80 °F assumes no heat transfer from payload to orbiter attach structure and no payload flow recirculation.
4. Duration and transient profile per Figure 5-4.
5. Bay 2 cooling not presently available (est 12/00).
6. Table shown for reference only.

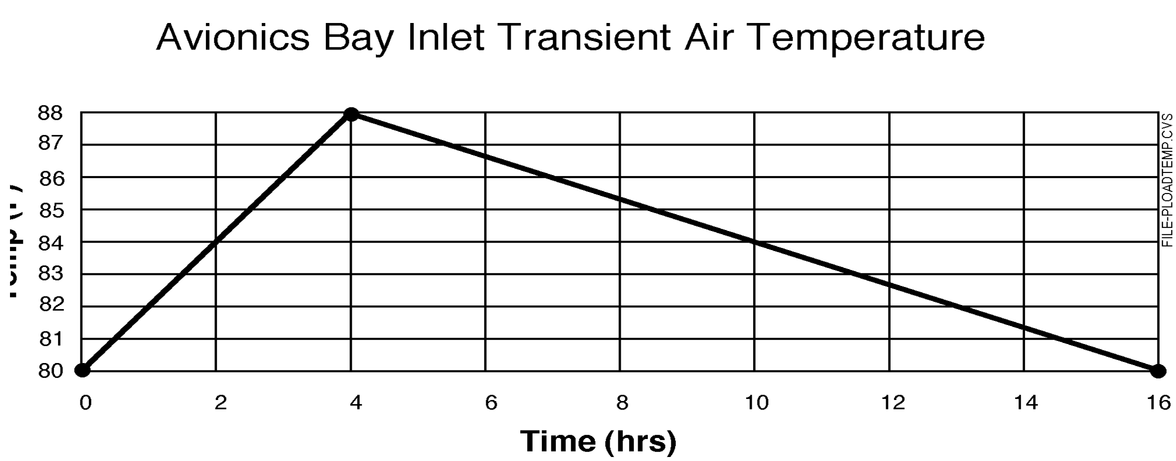


FIGURE 5-4 PAYLOAD INLET AIR TEMPERATURE PROFILE DURING ASCENT AND DESCENT (SHOWN FOR REFERENCE ONLY)

5.3.1.4.1.2.1 Bay 2 Standard Air Flow Capability

The standard orbiter air flow rate capability for an individual middeck payload will be 18 cfm. The amount of air available will be dependent upon the total orbiter payload manifest.

If payload air flow is greater than the orbiter-provided air flow, then payload air flow recirculation will occur. Inlet air temperature to the payload will be dependent upon the payload flow recirculation and payload heat dissipation. The effect of recirculation on the inlet air temperatures for orbiter flow rates will be shown in NSTS 21000-IDD-MDK. The delta T across the payload may be calculated from T_{out} minus payload inlet temperature.

5.3.1.4.2 Bay 3A Ducted Air Cooling Capability

Total bay 3A air cooling capability is as shown in Table 5-V.

5.3.1.4.2.1 Bay 3A Standard Air Flow Capability

The standard orbiter air flow rate capability for an individual middeck payload will be 18 or 36 cfm. Alternate air flow conditions are possible by unique orificing. The amount of air available will be dependent upon the total orbiter payload manifest.

If payload air flow is greater than the orbiter-provided air flow, then payload air flow recirculation will occur. Inlet air temperature to the payload will be dependent upon the payload flow recirculation and payload heat dissipation. Figures 5-5 and 5-6 show the effect of recirculation on the inlet air temperatures for orbiter flow rates of 18 cfm and 36 cfm, respectively. The delta T across the payload may be calculated from T_{out} minus payload inlet temperature.

5.3.1.4.3 Payload Limitations on Heat Conducted to Structure

All payload internal temperature requirements shall be met by heat rejection to only the middeck cabin ambient air and active air cooling circulated through the payload. Payloads do not need to be designed to be thermally isolated from the orbiter attach structure. Payloads shall not design to account for conducting payload heat to the orbiter attach structure. By design on the orbiter side, the conductive heat path through the orbiter attach structure will be small (≤5 %).

5.3.1.4.4 Payload Outlet Air Pressure Requirement

Air pressure at payload outlet shall be no greater than 0.1 in water.

TABLE 5-V MAXIMUM BAY 3A DUCTED AIR COOLING CAPABILITY

CABIN PRESSURE (psia)	COOLING CAPABILITY (W) (1)	FLOW RATE (cfm)	AVG DELTA T ACROSS P/L (°F) (5)	INLET TEMPERATURE (°F) (6)
14.7	1000	90 (3)	35 (3)	65 - 80 (Normal Operations) 95 Max Peak (Ascent/Descent) (7)
14.7	1000	180 (4)	17.5 (4)	65 - 80 (Normal Operations) 95 Max Peak (Ascent/Descent) (7)
10.2	700	90 (3)	35 (3)	65 - 80 (Normal Operations)
10.2	700	180 (4)	17.5 (4)	65 - 80 (Normal Operations)

NOTES:

1. Capability assumes no active air cooling required for TACAN support.
2. Capability assumes Ultra High Frequency (UHF) communications box installed in bay 3A.
3. Avionics fan capability dependent flow rate and delta T.
4. Cabin fan capability dependent flow rate and delta T.
5. Average payload delta T shown for reference.
6. Inlet temperature of 80 °F assumes no heat transfer from payload to orbiter attach structure and no payload flow recirculation.
7. Duration and transient profile per Figure 5-4.
8. Air cooling capability not available in all vehicles at this time.
9. Table shown for reference only.

5.3.1.4.5 Ducted Payload Air Pressure Requirement

The ducted air cooling functional interface for single and double payloads will be as defined in the following paragraphs. Ducted cooling configurations will be limited to four allowable configurations, one for single and three for double.

5.3.1.4.5.1 Single Size MDL Payload Air Cooling Interface

For single size MDL payloads, the air inlet and outlet functional interface will be as shown in Figure 3-13 (Sheet 1).

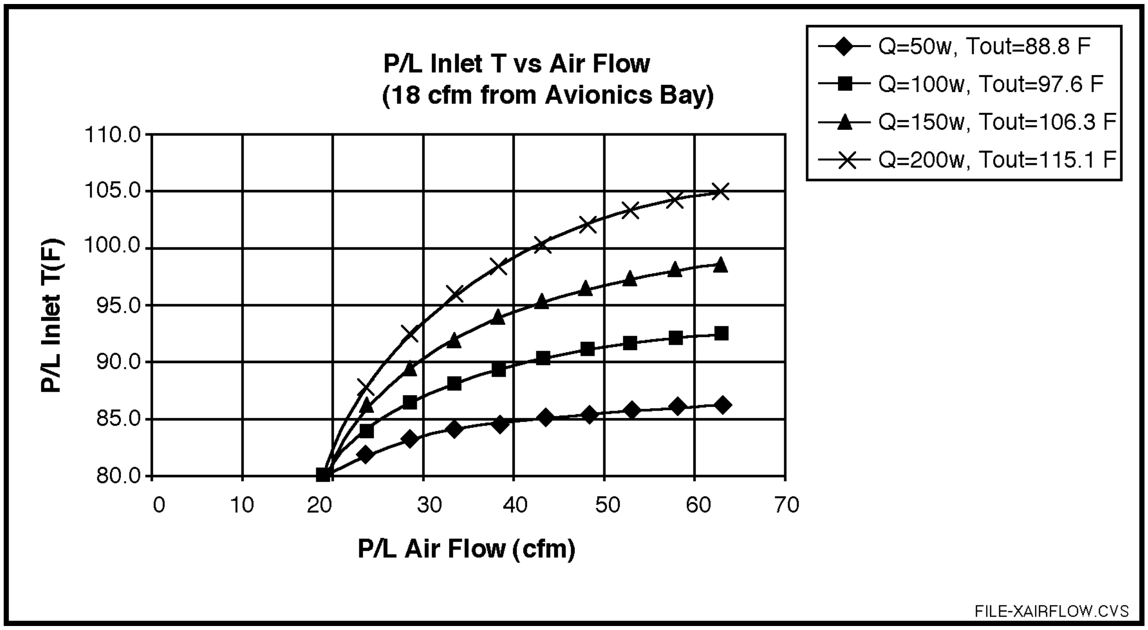


FIGURE 5-5 PAYLOAD INLET AIR TEMPERATURE WITH 18 CFM RECIRCULATION (SHOWN FOR REFERENCE ONLY)

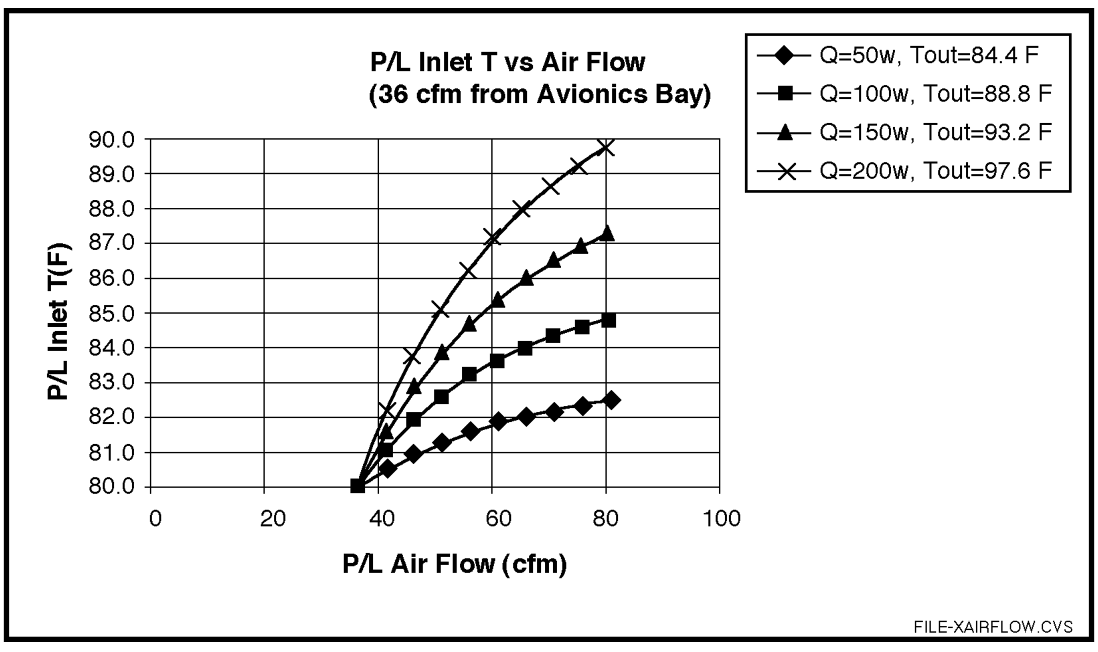


FIGURE 5-6 PAYLOAD INLET AIR TEMPERATURE WITH 36 CFM RECIRCULATION (SHOWN FOR REFERENCE ONLY)

5.3.1.4.5.2 Double Size MDL Payload Air Cooling Interface

For double MDL size payloads with their air inlets and outlets on the top half of the payload, the air cooling functional interface will be as shown in Figure 3-14 (Sheet 1) and Figure 5-2. With this configuration, payload flow may be greater than the orbiter outlet air flow. This configuration does not require a payload-provided minimum gap.

For double MDL size payloads with inlet on bottom half and outlet on top half of payload, the air cooling functional interface will be as shown in Figure 3-14 (Sheet 2).

Figure 3-14 (Sheet 2) configuration can be used if there a minimum of 0.75 in (19.1 mm) gap between the vented payload mounting panel and the payload to allow air recirculation from the plenum to air inlet. This gap may be part of payload design. With this configuration, payload flow may be greater than the orbiter outlet air flow.

Figure 3-14 (Sheet 3) can be used if there is no payload-provided minimum 0.75 in (19.1 mm) gap. This configuration requires the payload fan air flow rate to be less than or equal to the orbiter outlet air flow rate.

5.3.1.4.6 Cabin and Avionics Bay Air Mixing Limitations

Ducted air-cooled payloads shall be designed to preclude mixing of cabin and avionics bay air. Mixing of cabin and avionics bay air will be allowable for a maximum of 30 min per day, and the event must be crew-tended.

5.3.1.4.7 Ducted Payload Limitations on Heat Convected or Radiated to Cabin Air

Rejection of heat from the sides and front of a “ducted payload” to the cabin air by convection and radiation shall be limited to 10 percent of the payload’s total heat load.

5.3.1.4.8 Maximum Air Leakage Across Payload Mounting Interface Requirement

The maximum allowable air leakage at each locker interface, without contaminating the middeck air, shall be 2 scim at 0.5 inches of water.

5.3.1.5 Water Cooling Interface Requirements

The EXPRESS Rack provides two interface connections to the ISS moderate temperature water loop. A total of 200 lb/hr is available and will be suballocated to each payload by the rack integrator.

5.3.1.5.1 Physical Interface

Payloads requiring EXPRESS Rack-provided water cooling shall interface to the EXPRESS Rack-provided QD at the end of the water line as shown in Figure 5-7. Standard water lines and QDs will be provided to the PD from the ERO. The PD shall consider the QD in all of the required design analyses (e.g., leakage, ΔP, etc.).

5.3.1.5.2 Fluid Use

A. Payloads which connect to EXPRESS Rack water cooling system shall use fluids that meet the requirements specified in Table 5-VI.

B. Payloads which connect to EXPRESS Rack shall meet the fluid system cleanliness levels specified in Table 5-VII.

C. Payloads using EXPRESS Rack water cooling systems must use internal materials that are compatible according to MSFC-SPEC-250, Table III, or that shall not create a potential greater than 0.25 V with the ISS system internal materials due to a dissimilar metal couple.

D. The subrack payloads connected to the MTL shall be composed of wetted materials that do not include aluminum alloys nor alloys with greater than five percent copper. The MTL heat transport fluid is designed for use with stainless steel, nickel base and titanium alloys.

E. The subrack payloads connected to the MTL nonmetallic wetted surfaces shall be composed of materials that are non-nutrient to fungal growth inside the MTL systems.

The sampling location, frequency, and technique must provide representative samples of liquid or gas being tested to assure that, with the sampling approach utilized, the fluid meets the requirements at the interface. Table 5-VII specifies requirements at the interface; however, verification may be accomplished by sampling at an alternate location.

5.3.1.5.3 Water Quantity

Payloads shall have a maximum water volume of 3.7 liters.

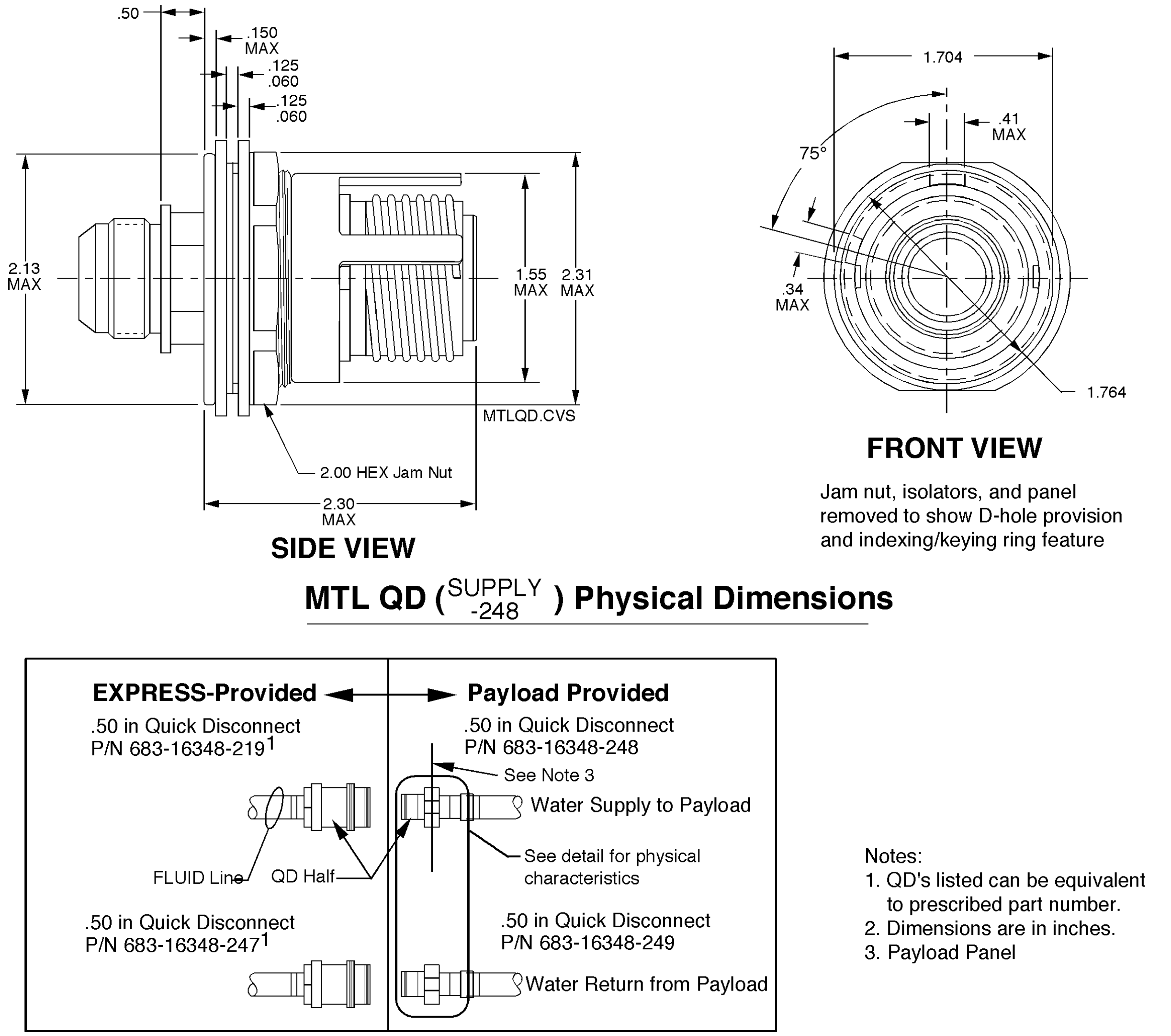


FIGURE 5-7 MODERATE TEMPERATURE WATER LOOP PHYSICAL INTERFACE

5.3.1.5.4 Thermal Expansion

Water-cooled payloads shall:

A. Arrive on-orbit fully charged with water as specified in SSP 30573 and

B. Allow for thermal expansion between 61 °F (16 °C) and 115 °F (46 °C) and

TABLE 5-VI HEAT TRANSPORT FLUID (INTERNAL ACTIVE THERMAL CONTROL) (Sheet 1 of 2)

CHARACTERISTICS	REQUIREMENTS	
	Procurement or Make to:	
Prior to Chemical Treatment: (Notes 7a, 7b, 7c)		
Conductivity (Note 1)	1.0×10^{-6} (1/ohm cm) (max)	
Chlorides (Note 2)	1.0 ppm (max)	
Dissolved Oxygen	6.0 ppm (min)	
Total Organic Carbon (Note 3)	1 ppm (max)	
Particles	N/A	
	As Delivered to Interface:	As Circulated in Flight Hardware:
Requirements after Chemical Treatment: (Notes 6)		
Chlorides (Note 2)	1.0 ppm (max)	1.0 ppm (max)
Dissolved Oxygen	6.0 ppm (min)	6.0 ppm (min)
Total Organic Carbon (Note 3)	5 ppm (max)	5 ppm (max)
Particles	(Note 9)	N/A
Di or Tri Sodium Phosphate	200 - 250 ppm as PO_4	200 - 250 ppm as PO_4
Sodium Borate ($NA_2B_4O_7$)	800 - 1200 ppm as B_4O_7 with additional 50 ppm allowed for pH adjustment	800 - 1250 ppm as B_4O_7
Silver Sulfate (Note 11)	0.1 ppm to 3 ppm	N/A
pH (Notes 4, 5, 7d)	9.5 ±0.1 adjusted using Sodium Hydroxide (NaOH)	9.5 ±0.5

NOTES:

1. Conductivity measurements shall be conducted in accordance with ASTM D 1125, Standard Test Method for Electrical Conductivity and Resistivity of Water.
2. Chlorides shall be determined in accordance with EPA Method 300.0, EPA Test Method for Chloride Ions in Water, or by other comparable methods demonstrated to be adequate for the sensitivity required.
3. The total organic carbon analysis shall be performed in accordance with the OI Corporate Model 700, Total Organic Carbon Analysis, analyzer or equivalent.
4. The pH specification for the coolant while operating in the Internal Active Thermal Control (IATC) loop will be in the band of 9.0 to 10.0.
5. The pH measurements shall be conducted in accordance with ASTM D 1293, Standard Method for pH in Water.

TABLE 5-VI HEAT TRANSPORT FLUID (INTERNAL ACTIVE THERMAL CONTROL) (Sheet 2 of 2)

6. Reagent grade chemicals shall be used in all heat transport fluid chemical treatments. Unless otherwise indicated, it is intended that all reagents shall conform to the specification of the Committee on Analytical Reagents of the American Chemical Society. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the coolant chemical concentration or contaminating the heat transport fluid.
7. Mixing and storage:
    a. Mixing and storage containers should be chemically cleaned and chemically treated or thermally treated to minimize microbial contamination.
    b. This shall be followed by flushing, prior to use, with high purity water that meets the “prior to chemical treatment” requirements from the table above (also see Note 1).
    c. Flush effluent from the container shall be sampled and tested for compliance with the conductivity requirements above.
    d. The pH shall be adjusted using sodium hydroxide solution after dissolution and mixing of borate and phosphate compounds. High pH overshoot can be corrected by increasing borate concentration up to an additional 50 ppm as noted in the table above.
8. Shipping and storage:
    a. Heat transport fluid shall be shipped and stored using procedures and shipping material which will not degrade the properties specified above.
9. Particulate control at system interface is specified in 4.1-1.
10. Materials compatibility: The IATC heat transport fluid is designed for use with stainless steel, nickel base and titanium alloys expected for use in the IATC and support equipment. Aluminum alloys and alloys with greater than five percent copper are not to be used in the IATC heat transport fluid.
11. Nonmetallic materials used in the IATC should not support microbial growth inside the IAC. Target initial make-up of coolant to a concentration of 3 ppm silver. The silver concentration is expected to decrease with time because of interaction of silver with metals in coolant make-up and servicing systems.

C. Contain a suitable concept or expansion device that actuates at a pressure greater than 100 psia (690 kPa) while connected to the EXPRESS Rack or ITCS.

Note: Transportation temperature ranges are from 35 ºF (1.67 ºC) to 120 ºF (48.9 ºC).

5.3.1.5.5 Water Loop Pressure Drop

The pressure drop between the inlet and outlet QDs (including the QDs and connecting hoses) of payloads utilizing the EXPRESS Rack water cooling system interface shall be 2.80 ± 0.15 psid (19.3 ± 1.03 kPa) at the desired flow rate.

TABLE 5-VII THERMAL CONTROL (IATC) INTERNAL

FLUID	SUPPLY SYSTEM	PARTICULATE CONTROL	
		SUPPLY INTERFACE/FINAL FILTER MAX. PARTICLE RATING	SYSTEM/SUPPLY SYSTEM SURFACE CLEANLINESS LEVEL PER MIL-STD-1246A (NOTE 3)
<u>Operational Fluids</u>:			
Heat Transport Fluid (IATC)	GSE, FSE	2 micron	Level 300 A
Nitrogen/N_2	ECLSS	25 micron	Level 200 A
<u>Assembly Fluids</u>:			
Argon/Ar	GSE	2 micron	(Note 2)
<u>Cleaning, Flushing, and Testing Fluids (Note 1)</u>			
Alcohol (Isopropyl)	GSE	25 micron	(Note 2)
Argon/Ar	GSE	2 micron	(Note 2)
Helium/He	GSE	25 micron	(Note 2)
Nitrogen/N_2	GSE	25 micron	(Note 2)
Water (High Purity Deionized)	GSE	40 micron	(Note 2)

NOTES:

1. Fluids utilized for system cleaning on a continuous basis shall be sampled at least every 8 hours and controlled in accordance with SSP 30573.
2. The assembly, cleaning, flushing, and testing fluid surface cleanliness requirement is the same as the surface cleanliness level required by the operational system this fluid is to be used within.
3. MIL-STD-1246, Revision A, Military Standard Product Cleanliness Levels and Contamination Control Program, is used as exceptions to the SN-C-0005, Revision C, standard, Specification, Contamination Control Requirements for the Space Shuttle Program.

5.3.1.5.6 QD Air Inclusion

Payload-provided QD air inclusion shall be less than or equal to .30 cubic centimeters (cc) maximum per mate/demate cycle.

5.3.1.5.7 Leak Rate

The total allowable leakage by the payload equipment shall be less than 0.002 cc/hr of H_2O at 125 psia +5 -3 psia at 70 ± 5 °F. This includes any water loss due to mate/demate of the QDs.

5.3.1.5.8 Water Coolant Flow Rate

Payloads requiring water cooling system shall be designed to a value within the following available range: 50 to 200 lbm/hr, based on 0.0975 lbm/hr water flow per watt.

The flow rate to the payload cannot be adjusted to a different value once the payload is integrated into the EXPRESS Rack.

5.3.1.5.9 Water Coolant Supply Temperature

Payloads shall be compatible with water cooling system water supplied at a non-selectable temperature within the following range: 61 to 73.4 ºF (16.1 to 23 ºC).

5.3.1.5.10 Water Coolant Return Temperature

The maximum return temperature from the payload to the cooling system water loop shall be less than 120 °F (48.9 °C).

5.3.1.5.11 Maximum Water Coolant System Pressure

Payloads shall be compatible with the water coolant system loop MDP of 121 psia (834 kPa) with safety factors in accordance with SSP 52005, paragraph 5.1.3.

Note: The maximum allowable heat dissipation for the integrated EXPRESS Rack is limited to 2,000 W for all water-cooled and air-cooled payload hardware items and will be suballocated to each individual payload by the ISS.

5.3.2 USL/APM/JEM/Centrifuge Accommodation Module (CAM) Unique Thermal Control Interface Requirements

The combined cabin air heat loads (from all payloads and payload racks operating simultaneously) shall not exceed the allowable heat load capacity requirements limits of Table 5-VIII.

TABLE 5-VIII CABIN AIR HEAT LOAD CAPACITY REQUIREMENTS

	ISS LAB			
	APM	USL	JEM	CAM
All racks total in Module	500 W	500 W	250 W	500 W
Integrated EXPRESS Rack	38 W	38 W	19 W	38 W

5.4 VACUUM EXHAUST SYSTEM/WASTE GAS SYSTEM INTERFACE REQUIREMENTS (USL, APM, JEM)

The EXPRESS Rack provides one interface to the ISS Vacuum Exhaust System/Waste Gas System (VES/WGS). The EXPRESS Rack does not provide an interface to the ISS VRS.

5.4.1 Physical Interface (USL, APM, JEM)

Payloads requiring ISS-provided VES/WGS vacuum exhaust services shall interface to the EXPRESS Rack-provided QD at the end of the VES/WGS lines as shown in Figure 5-8. Standard vent lines and QDs will be provided to the PD from the ERO. The PD must consider the QD in all of the required design analyses (e.g., leakage, ΔP, flow, etc.).

5.4.2 Input Pressure Limit (USL, APM, JEM)

The maximum interface pressure (i.e., MDP) from the payload to the VES/WGS shall be≤40 psia (276 kPa).

5.4.3 Input Temperature Limit (USL, APM, JEM)

The initial input temperature of gases disposed into the VES/WGS by the payload shall be 60 to 113 °F (16 to 45 °C).

5.4.4 Input Dewpoint Limit (USL, APM, JEM)

The initial dewpoint of gases disposed into the VES/WGS by the payload shall be ≤60 °F (15.5 °C).

5.4.5 Vacuum Exhaust System (VES)/Waste Gas System (WGS) MDP

The MDP of the VES/WGS is 40 psia (276 kPa). PD hardware shall be compatible with this MDP (using the safety factors specified in SSP 52005, paragraph 5.1.3) and be two fault tolerant against failure conditions which would exceed VES/WGS MDP.

Note: The EXPRESS Rack provides a pass through for access to the VES/WGS.

5.4.6 Leak Rate (USL, APM, JEM)

The total allowable leakage by the payload equipment including payload provided quick disconnect and hoses shall be less than 5×10^{-4} sccs of GHe at 40 psia equivalent at 70 ± 5 °F (18 to 23.9 °C).

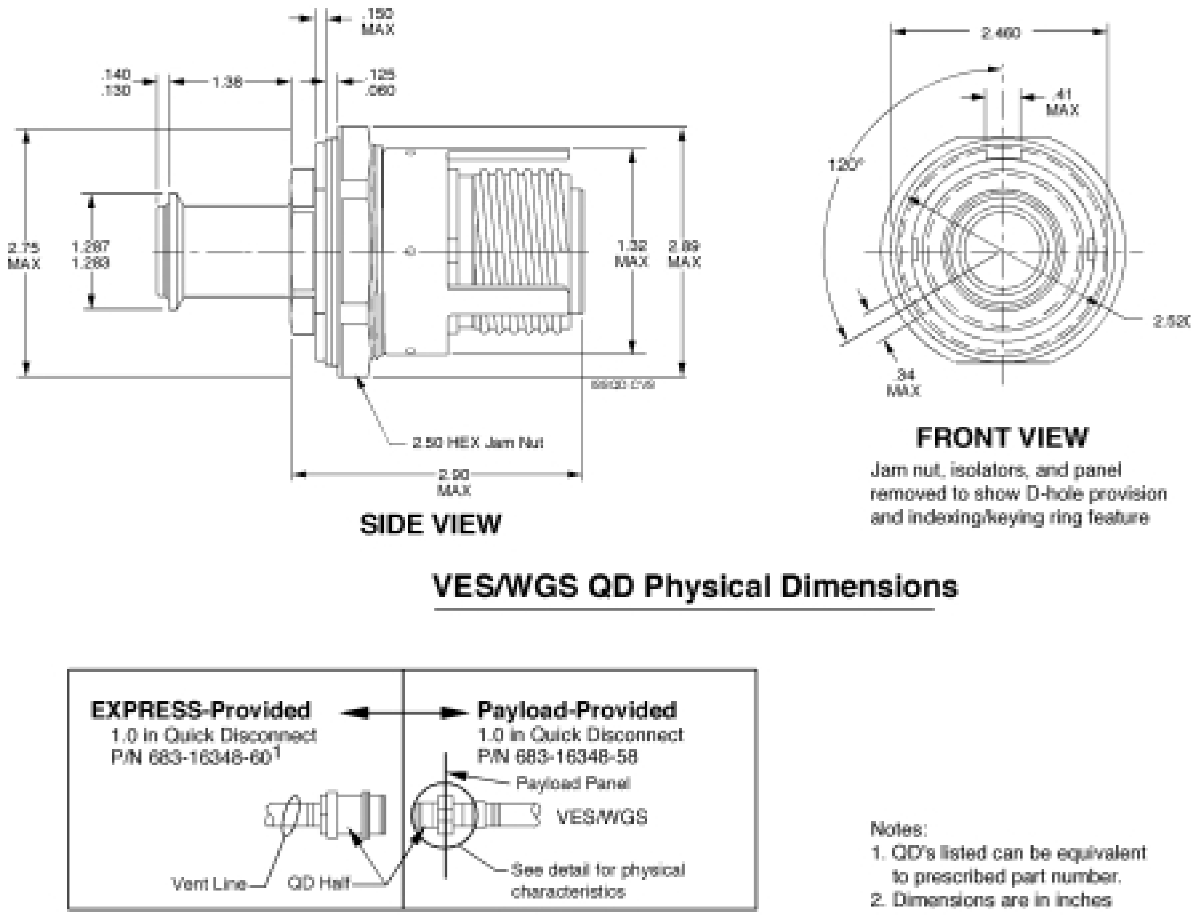


FIGURE 5-8 VES/WGS PHYSICAL INTERFACE

5.4.7 Acceptable Effluents (USL, APM, JEM)

Payload gases disposed into the ISS VES/WGS shall be compatible with the vacuum exhaust wetted materials of construction. Wetted materials are provided in Table 5-IX, VES/WGS Wetted Materials.

5.4.7.1 Acceptable Gases (USL, APM, JEM)

A. Gases compatible with the ISS VES/WGS are listed in Table 5-X, Acceptable Gases. A payload shall submit a list of all proposed vent gas constituents, initial volume, concentration, temperature, and pressure to the rack integrator. Gases not included on the list will be evaluated for compatibility with the ISS VES/WGS by the ISS Lab integrator.

TABLE 5-IX VACUUM EXHAUST SYSTEM WETTED MATERIALS

	ISS LABORATORIES			EXPRESS RACK UNIQUE
	USL	APM	JEM	
Stainless Steel 316				X
Stainless Steel 321 and 450	X			
Titanium 6 AL-4V	X			
Fluorocarbon rubber (Viton)	X			
Glass	X			
Platinum-iridium Alloy	X			
Gold-Plated Brass	X			
Ceramic	X			
Aluminum	X			
Tetrafluoroethylene (Teflon)	X			
Stainless Steel (300 series), passivated surface		X		
AIMgSil, AA, 6061-T6, 3.3214, hard anodized or Alodine 1200		X		
Butyl Rubber (Buna N)		X		
Silicon Elastomer (Silastic X5-8005)		X		
Teflon Impregnation of hard anodize		X		
Nickel Alloy, Ni 99.2, 2.4066		X		
X5 CrNiNb 18 10, AISI 347, 1.4546.9		X		
Tungsten (heated) (Wolfram)		X		
Fluor Rubber (Viton A)		X		
Bronze, CuSn 89/11 (ECKA Bronze etain 89/11 AK)		X		
Nickel-Base Alloys (Inconel 600, 625, 718)			X	
Wire Alloy X750 (AMS 5678)			X	
Stainless Steel (CRES 304L, 347)			X	
Aluminum, Anodized (6061-T6, T651)			X	
Braze 82NI, 4, 5SI 7CR 3FE 3, 1B (AMS 4777)			X	
Platinum			X	

TABLE 5-X ISS ACCEPTABLE EXHAUST GASES (Sheet 1 of 4)

GAS	MAX CONCENTRATION	ISS LABORATORIES			ADDITIONAL CONSTRAINTS
		USL	JEM	APM	
Acetaldehyde	100%	X			
Acetic Acid	100%	X			
Acetonitrile	100%	X			
Acetylene	100%	X			
Acrolein	100%	X			
Acrylonitrile	100%	X			
Argon	100%	X	X		
Benzene	100%	X			Note 3
Benzonitrile	100%	X			Note 3
1, 3-Butadiene	100%	X			
n-Butane	100%	X			
Butene	100%	X			
1-Butene	100%	X			
2-Butanone	100%	X			
Cabin Air	100%	X	X		Note 1
Carbon Dioxide	100%	X	X		
Carbon Monoxide	100%	X	X		Note 4
Chlorobenzene	100%	X			Note 3
Chloroethane	100%	X			
Chloromethane	100%	X			
cis-2-Butene	100%	X			
1,3-Cyclopentadiene	100%	X			
Cyclopentanone	100%	X			Note 3
Cyanogen chloride	100%	X			
Cyanogen bromide	100%	X			Note 3
n-Decane	100%	X			Note 3
1,1-Dichloroethane	100%	X			Note 3
1,1-Dichloroehtene	100%	X			Note 3

TABLE 5-X ISS ACCEPTABLE EXHAUST GASES (Sheet 2 of 4)

GAS	MAX CONCENTRATION	ISS LABORATORIES			ADDITIONAL CONSTRAINTS
		USL	JEM	APM	
Dichloromethane	100%	X			Note 3
Ethane	100%	X			
Ethene	100%	X			
Ethanol	100%	X			
Ethyl benzene	100%	X			Note 3
Ethyl isopropyl ether	100%	X			Note 3
Ethyl methyl ether	100%	X			
2-Ethyl-4-Methyl-1,3-Dioxolane	100%	X			Note 3
Ethyl n-Propyl Ether	100%	X			Note 3
Formaldehyde	100%	X			
Helium	100%	X	X		
n-hexanal	100%	X			Note 3
Hexane	100%	X			Note 3
Heptane	100%	X			Note 3
Hydrogen	100%	X	X		
Hydrogen cyanide	100%	X			
Hydrogen sulfide	100%	X			
Isopropanol	100%	X			
Isopropyl formate	100%	X			Note 3
Krypton	100%	X	X		
Methane	100%	X	X		
Methanol	100%	X			
Methyl acetate	100%	X			
Methyl acrylate	100%	X			Note 3
2-Methyl-2-butenal	100%	X			Note 3
1-(1-Methylethoyx)-2-Propanone	100%	X			Note 3
Methyl formate	100%	X			

TABLE 5-X ISS ACCEPTABLE EXHAUST GASES (Sheet 3 of 4)

GAS	MAX CONCENTRATION	ISS LABORATORIES			ADDITIONAL CONSTRAINTS
		USL	JEM	APM	
Methyl methacrylate	100%	X			Note 3
2-Methyl propane	100%	X			
2-Methyl propene	100%	X			
Mixtures of gases in Appendix D1	100%	X			Note 2
Neon	100%	X	X		
Nitrogen	100%	X	X		
Norflurane	100%	X			Note 3
Octane	100%	X			Note 3
o-Xylene	100%	X			Note 3
Oxygen	not more than 30% by volume vented from the experiment chamber	X	X		
Pentanal	100%	X			Note 3
Pentane	100%	X			
Propadiene	100%	X			
Propane	100%	X			
Propanol	100%	X			
2-Propanone	100%	X			
Propene	100%	X			
n-Propyl acetate	100%	X			Note 3
Propyl formate	100%	X			Note 3
n-Propyl isopropyl ether	100%	X			Note 3
Propyne	100%	X			
Radon	100%	X			
Styrene	100%	X			Note 3
Sulfur dioxide	100%	X			
Sulfur Hexafluoride	100%	X	X		

TABLE 5-X ISS ACCEPTABLE EXHAUST GASES (Sheet 4 of 4)

GAS	MAX CONCENTRATION	ISS LABORATORIES			ADDITIONAL CONSTRAINTS
		USL	JEM	APM	
tert-Butyl alcohol	100%	X			
Toluene	100%	X			Note 3
1,1,1-Trichloroethane	100%	X			Note 3
Trichlorofluoroethane	100%	X			Note 3
1,2,4-Trimethylbenzene	100%	X			Note 3
2,2,4-Trimethyl-1,3-dioxolane	100%	X			Note 3
Vinyl acetate	100%	X			Note 3
Vinyl Chloride	100%	X			
Water vapor	100%	X			
Xenon	100%	X			
m-Xylene	100%	X			Note 3

NOTES:

1. Vented cabin air will contain small percentages of additional gases at up to the maximum levels defined in SSP 41000, Table VII, Spacecraft Maximum Allowable Concentrations (SMAC), or NHB 8060.1B, Appendix D. If the gases are not referenced in the above documents, the PD must use the Materials and Processes Technical Information System (MAPTIS) SMAC values. If MAPTIS is used, the PD must provide documentation for the SMAC values (including the date the information was taken from MAPTIS) as MAPTIS is not under configuration control.
2. Combinations of all gases must be analyzed and are constrained as specified to paragraph 5.4.7.1B; this table only represents the gases that are compatible with the ISS Vacuum Systems wetted materials.
3. Each proposed vent gas with a molecular weight greater than 75 amu must be analyzed in accordance with 5.4.7.1.B.
4. Maximum concentration of carbon monoxide exhausted JEM VES/WGS is not more than 0.08% by volume.
5. The list of acceptable exhaust gases has not been finalized for the APM.
6. The following gases must be containerized, stored or transported by the PD unless the concentrations of the gases are no more than the maximum levels defined in SSP 41000, Table VII; Spacecraft Maximum Allowable Concentrations (SMAC) or NHB 8060.1B, Appendix D: hydrogen bromide, hydrogen chloride, hydrogen fluoride, hydrogen iodide, nitric acid, nitrogen dioxide, nitrogen tetroxide, perchloric acid, phosgene, phosphoric acid and sulfuric acid. If the gases are not referenced in the above documents, the PD must use the Materials and Processes Technical Information System (MAPTIS) SMAC values. If MAPTIS is used, the PD must provide documentation for the SMAC values (including the date the information was taken from MAPTIS) as MAPTIS is not under configuration control.

B. Payload exhaust gases vented to the ISS VES/WGS shall be non-reactive with other vent gas mixture constituents.

C. Payloads venting to the ISS VES/WGS shall provide a means of removing gases that would adhere to the ISS VES/WGS tubing walls at a wall temperature of 40 ºF (4 ºC) and at a pressure of 10^{-3} torr.

D. Payloads venting to the ISS VES/WGS shall remove particulates that are larger than 100 micrometers in size from vent gases.

5.4.7.2 External Contamination Control (USL, APM, JEM)

Payload gases disposed into the VES/WGS shall meet the requirements of Section 3.4 of SSP 30426, Space Station External Contamination Control Requirements, for molecular column density, particulates, and molecular deposition on external ISS surfaces.

5.4.7.3 Incompatible Exhaust Gases (USL, APM, JEM)

A. The EXPRESS Rack payload shall provide containment, storage, and transport hardware for gases that are incompatible with the vacuum exhaust or external environment.

B. Contaminant hardware for incompatible exhaust gases shall meet the redundant container requirements specified in NSTS 1700, Section 209.1b.

5.4.8 Utility Control

The PD shall incorporate an isolation valve within the payload design. If a manual isolation valve is used, it shall be accessible from the front of the rack.

5.5 GASEOUS NITROGEN (GN_2) INTERFACE REQUIREMENTS

The only standard inert gas available to EXPRESS Rack payloads is GN_2.

5.5.1 Physical Interface

Payloads requiring GN_2 shall interface to the EXPRESS Rack-provided QD at the end of the GN_2 lines as shown in Figure 5-9. GN_2 lines with QDs and mating QD halves will be provided to the PD from the ERO as identified in the EIA. The PD must consider the QD in all of the required design analyses (e.g., leakage, ΔP, flow, etc.).

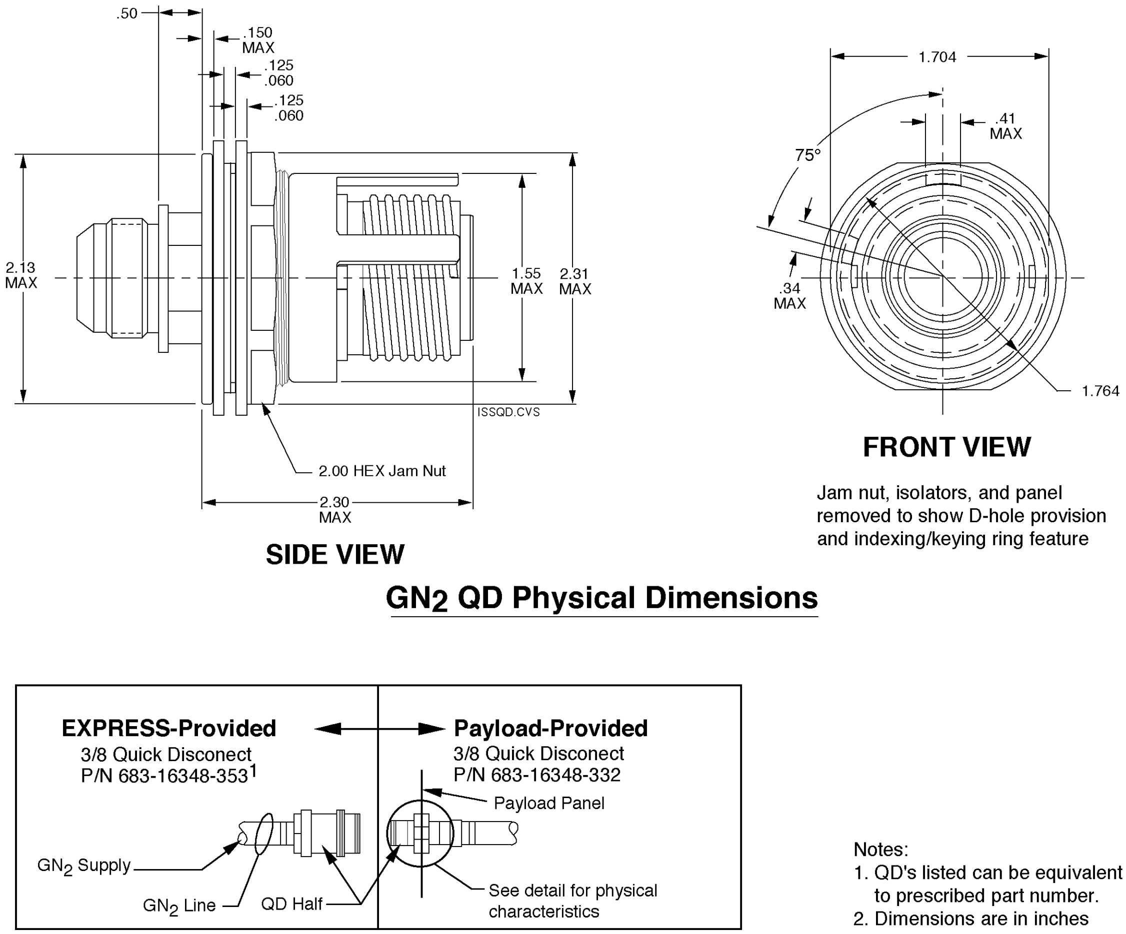


FIGURE 5-9 GN_2 PHYSICAL INTERFACE

5.5.2 Utility Control

The PD shall provide a valve located within the payload volume to control and isolate the flow of GN_2 to not exceed $12\ \frac{\text{lbm}}{\text{hr}}\left(5.43\ \frac{\text{kg}}{\text{hr}}\right)$. If a manual valve is employed, the valve shall be accessible from the front of the rack.

5.5.3 GN_2 System MDP

All PD hardware shall be compatible with an MDP of 200 psia for the GN_2 supply with safety factors in accordance with SSP 52005, paragraph 5.1.3.

5.5.4 Interface Pressure (USL, APM)

The payload hardware shall be compatible with a GN_2 interface pressure range of 75 to 120 psia (517 to 827 kPa).

5.5.5 Temperature

The payload hardware shall be compatible with a GN_2 interface temperature range of 60 °F to 120 °F (15 °C to 49 °C).

5.5.6 Leak Rate

The total allowable leakage by the PD equipment including payload provided quick disconnect and hoses shall be less than 5×10^{-4} sccs of GN_2 at 200 psia equivalent at 70 ± 5 °F (18 to 23.9 °C).

5.5.7 GN_2 Characteristics

The PD hardware shall be:

A. Compatible with the GN_2 supplied by the ISS per Table 5-XI (reference SSP 30573) and

B. Charged with GN_2 Grade C to a pressure no greater than 70 psia (480 kPa) and

C. Meet the fluid system cleanliness requirements specified in Table 5-VII.

TABLE 5-XI PAYLOAD NITROGEN QUALITY

CHARACTERISTICS	REQUIREMENTS
Nitrogen, minimum % by volume	99.995
Total Impurities, ppm	50.0
Total Hydrocarbons ppm as CH_4	5.0
Halogenated Solvents	N/A
Oxygen, ppm	20.0
Argon, ppm	2.0
Water, ppm	5.7
Dewpoint, °F, @ 70 °F (21.1 °C), (760 mmHg)	-84
Hydrogen, ppm	0.5
Carbon Dioxide, ppm	5.0
Carbon Monoxide, ppm	5.0
Aromatic Hydrocarbons (as Benzene)	0.5 ppm (max)
Halogenated Hydrocarbons	0.1 ppm (max)
Chlorinated Hydrocarbons	0.1 ppm (max)
Nitrous Oxide	1.0 ppm (max)
Odor	None detectable

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SECTION 6, ELECTRICAL POWER INTERFACES

6.1 ELECTRICAL POWER/ENERGY

6.1.1 Baseline Power Allocation

The payload design should minimize electrical power requirements. There is no ascent/descent or on-orbit power available in the MPLM for EXPRESS Racks or EXPRESS Transportation Racks. There are no ac power resources available in the EXPRESS Rack. The EXPRESS Rack converts ISS +120 Vdc power to +28 Vdc power for payloads. Total payload power usage is limited by thermal constraints (defined in paragraph 5.3).

6.1.2 Shuttle/Middeck Power and Voltage

The Shuttle middeck and aft flight deck provide both 28 ± 4 Vdc and 115 ± 5 Vac electrical service via various power panels shown in NSTS 21000-IDD-MDK, Section 7, Figures 7.2.1.3-1 and 7.3.1.1-1. All power interfacing cables are Shuttle provided. The power characteristics of these interfaces are shown in Figures 6-1, 6-2, and 6-3.

6.2 EXPRESS RACK DC POWER CHARACTERISTICS

The following paragraphs define all of the “design to” requirements for payloads which interface to the EXPRESS electrical power subsystem.

6.2.1 28 Vdc Power and Voltage

The EXPRESS Rack provides 28 + 1.5/-2.5 Vdc power to the payloads which are integrated into the rack. This includes the worst-case interface cable voltage drop. The physical connections are either via connections on the EXPRESS Rack upper or lower connector panels for each MDL payload or via “blind” self-mating connectors in the rear of the EXPRESS Rack for ISIS drawer-mounted payloads. The EXPRESS Rack panels also provide an “ON/OFF” toggle switch for manual power control to each EXPRESS Rack payload position (both MDL and ISIS drawer).

6.2.1.1 Voltage Levels

Payloads shall be compatible with the interface voltage levels as shown in Figure 6-4. This figure is applicable at current ranges of 1.0 to 20.0 A. This figure is applicable to turn “ON” and turn “OFF” events.

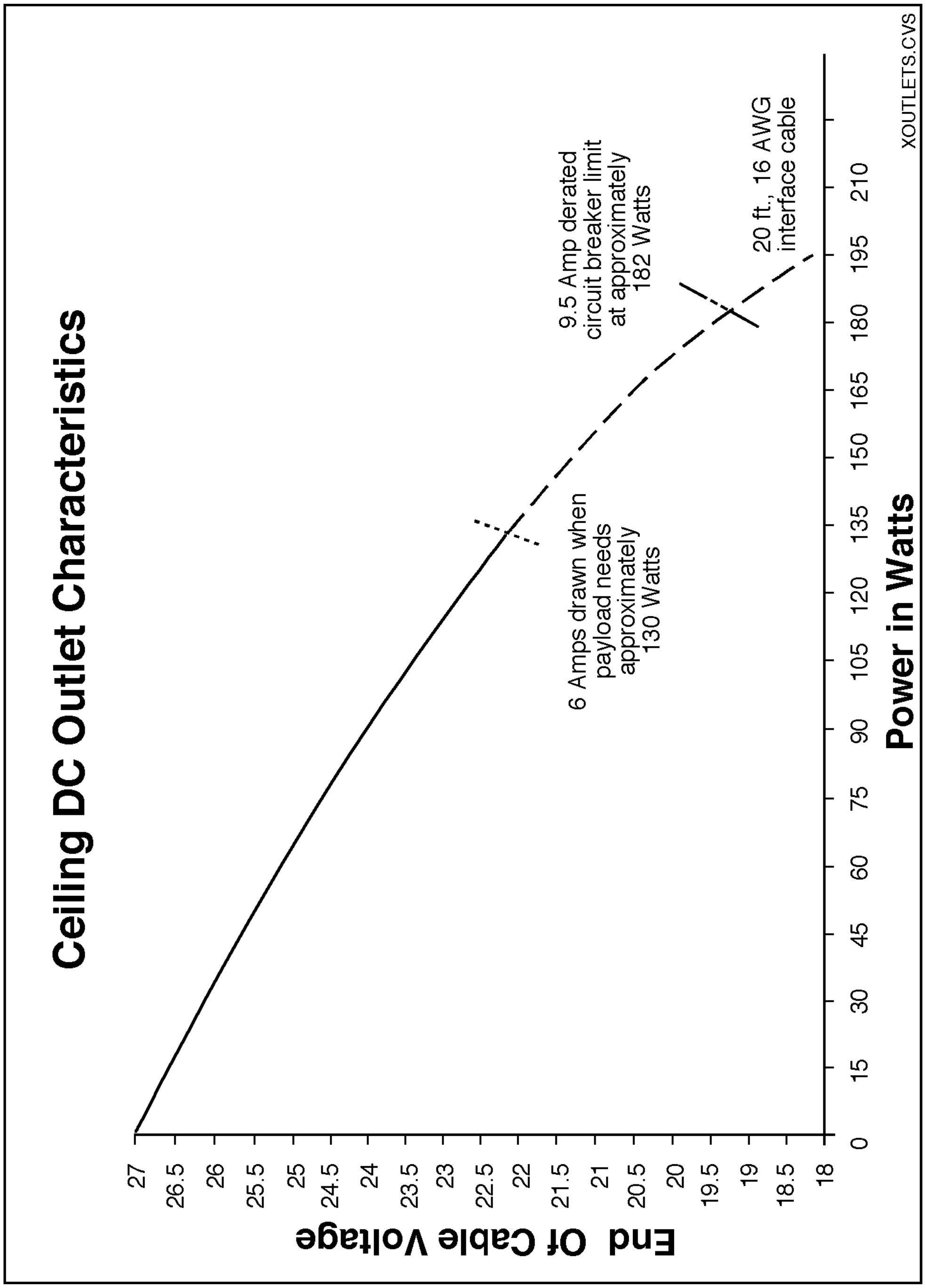


FIGURE 6-1 CEILING DC OUTLET CHARACTERISTIC (CONTROLLED IN THE MIDDECK IDD)

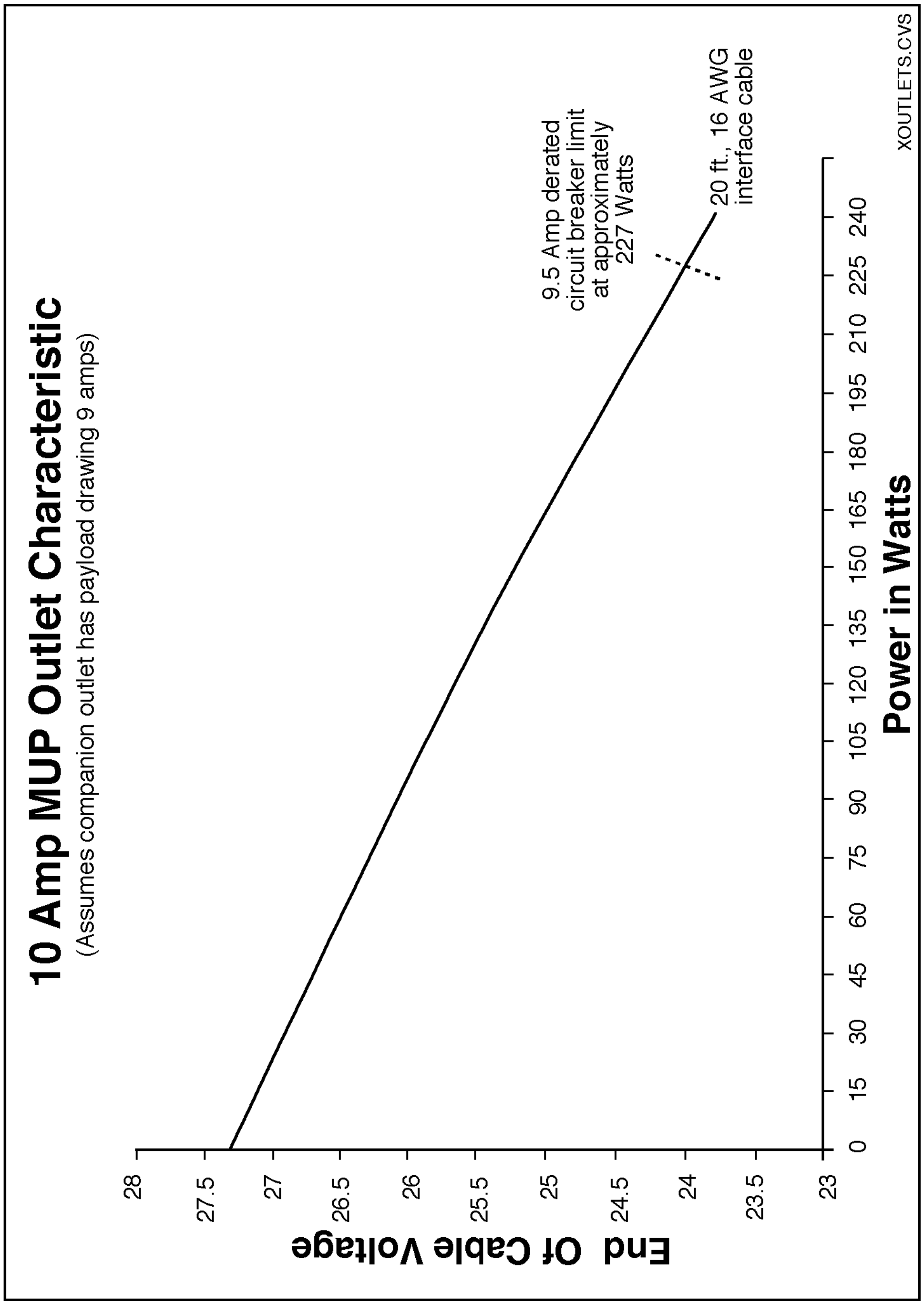


FIGURE 6-2 10-A MUP CHARACTERISTIC (CONTROLLED IN THE MIDDECK IDD)

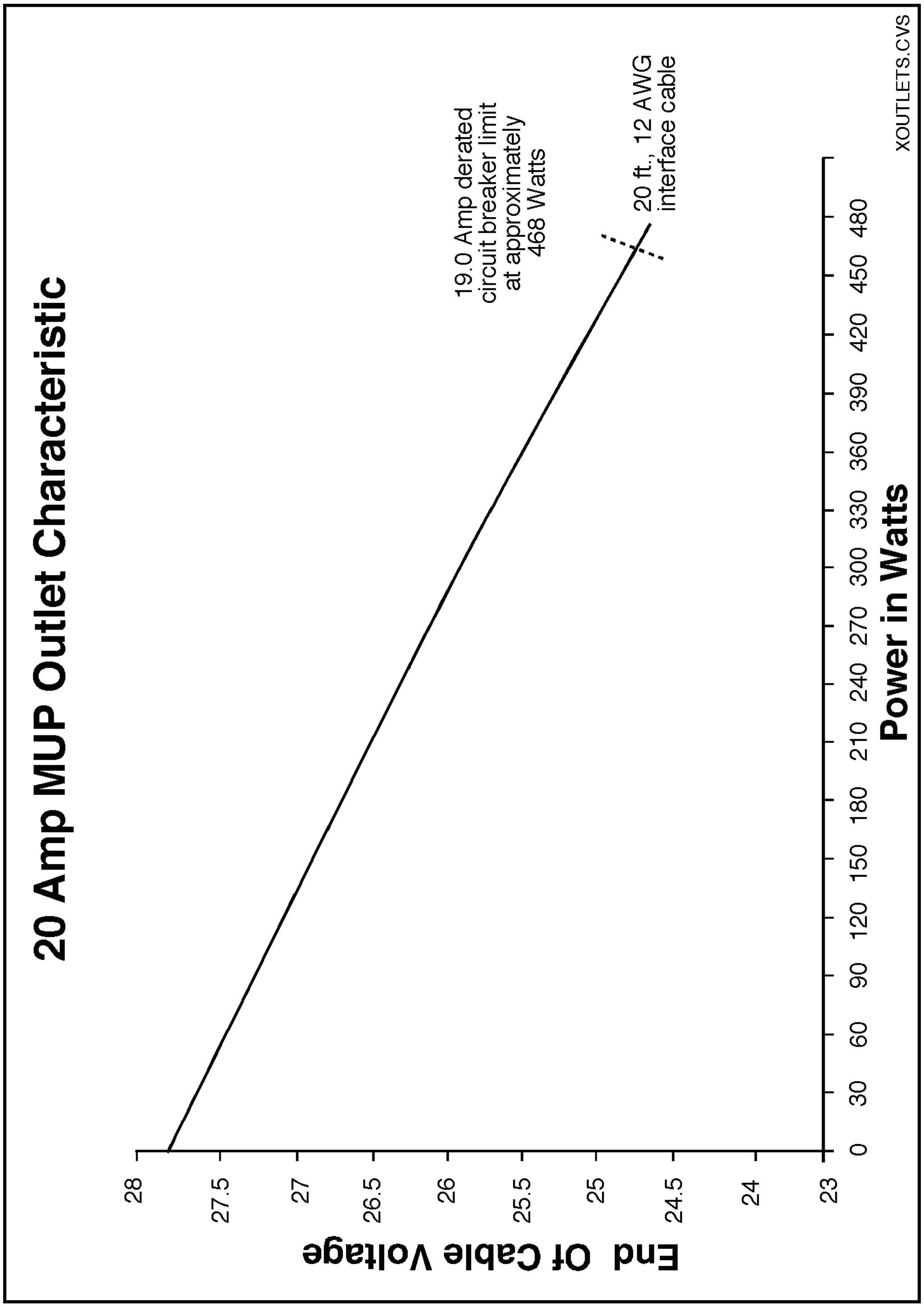


FIGURE 6-3 20-A MUP OUTLET CHARACTERISTICS (CONTROLLED IN THE MIDDECK IDD)

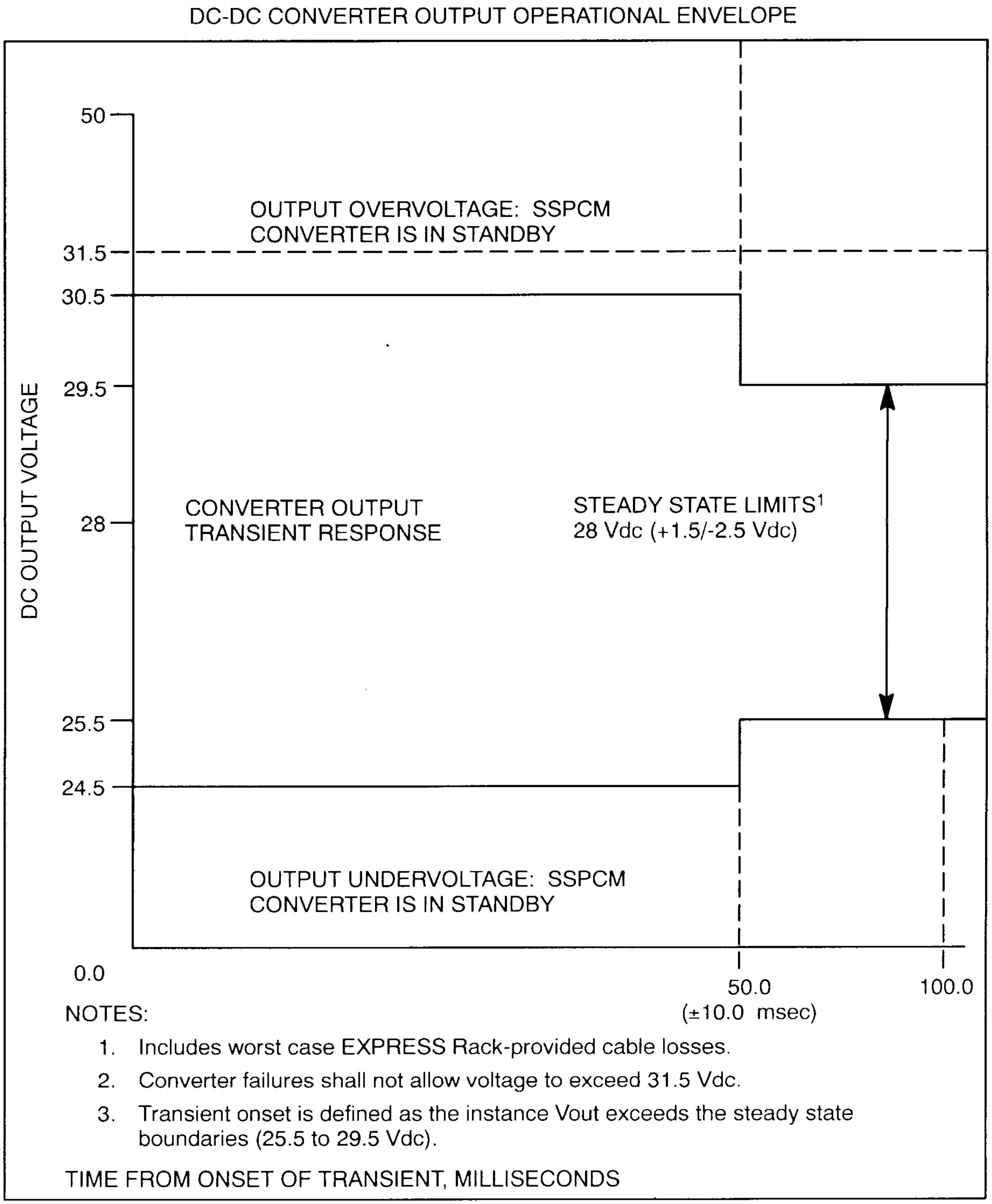


FIGURE 6-4 1-A TO 20-A (PAYLOAD CURRENT DRAW), 28 VDC OUTLET CHARACTERISTIC

6.2.1.2 Output Impedance

The output resistance for each of the power outputs of the EXPRESS Rack is defined in Table 6-I.

TABLE 6-I EXPRESS RACK POWER PERFORMANCE VALUES

POWER PARAMETER	LIMITS/RATING	VALUE
Output Resistance	+28 Vdc/20 A	30.0 mohms[2]
Reverse Current	Pulse t < 10 µsec	600 A
	Peak t < 1 msec/All Ratings	450 A
	Steady-State (t > 1 sec)/All Ratings	2 A
Reverse Energy		
Capacitive	All Ratings	4 Joules
Inductive	All Ratings	2 Joules

NOTES:
1. Temperature reference is 25 °C.
2. Output resistance value does not include EXPRESS Rack cable resistance.

6.2.1.3 Reverse Current

Reverse current is defined as the current flowing into a Solid-State Power Controller Module (SSPCM) power output from an external source of energy. The reverse current limitation requirements for which each payload connection shall comply are defined in Table 6-I.

6.2.1.4 Reverse Energy

Reverse energy is defined as the energy flowing into an SSPCM power output from an external source of energy. The reverse energy limitation requirements for which each payload connection shall comply are defined in Table 6-I.

This requirement can also be satisfied when the analysis shows the payload's input is capacitive and ≤50 µF/A of the Solid State Power Controller (SSPC) rated output current.

6.2.1.5 Soft Start/Stop

The SSPC provides a soft start/stop of approximately 1 msec to reach nominal current or to turn "OFF".

6.2.2 Overload Protection

The dc power is provided to each payload via software commandable SSPCMs. Refer to Figure 6-5 for a simplified schematic of the power distribution subsystem. Each SSPC may be set via software commands to output current ratings of 5 A, 10 A, 15 A, and 20 A. The trip characteristics for the SSPCs are presented in Figure 6-6. The family of curves is indicated for 5-A, 10-A, 15-A, and 20-A SSPCM settings.

6.2.2.1 Overload Protection Device

The payload shall provide an overload protection device in the power input lines.

6.2.2.1.1 Device Accessibility

A payload overload protective device shall not be accessible without opening a door or cover, except that an operating handle or operating button of a circuit breaker, the cap of an extractor-type fuse holder, and similar parts may project outside the enclosure.

6.2.2.1.2 Location

Payload overload protection devices (fuses and circuit breakers) intended to be manually replaced or physically reset on orbit shall be located where they can be seen and replaced or reset without removing other components.

6.2.2.1.3 Device Identification

Each payload protector (fuse or circuit breaker) intended to be manually replaced or physically reset on orbit shall be readily identified or keyed for its proper value.

6.2.2.1.4 Extractor-Type Fuse Holder

The design of the extractor-type fuse holder shall be such that the fuse is extracted when the cap is removed.

6.2.3 Current Limiting

A. The SSPC is a current limiting device. Each power output of the SSPCM will limit the current within 100.0 µs of an over current to a value less than the maximum current limit value as depicted in Figure 6-6. The payload equipment shall be compatible with this specification.

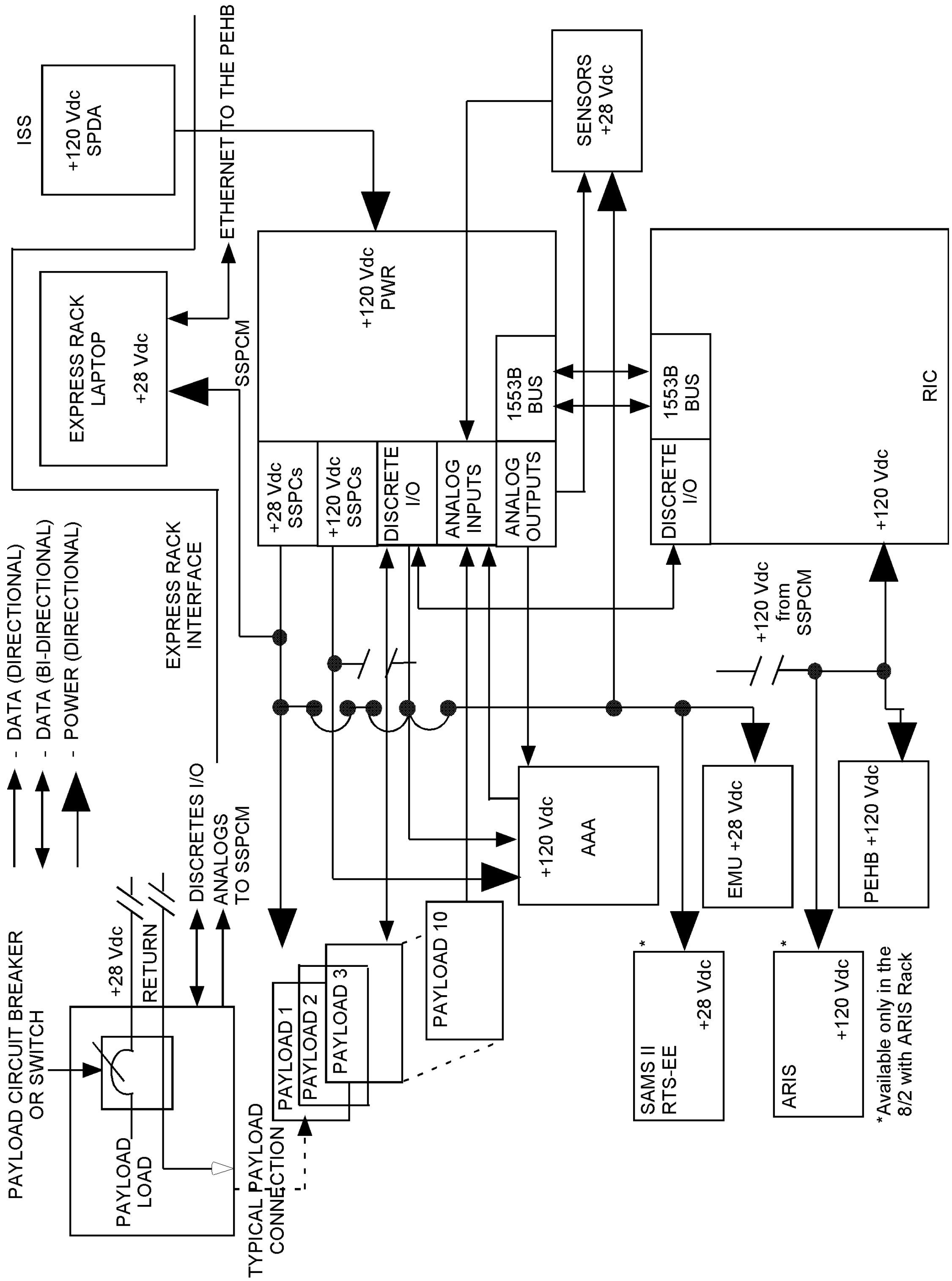
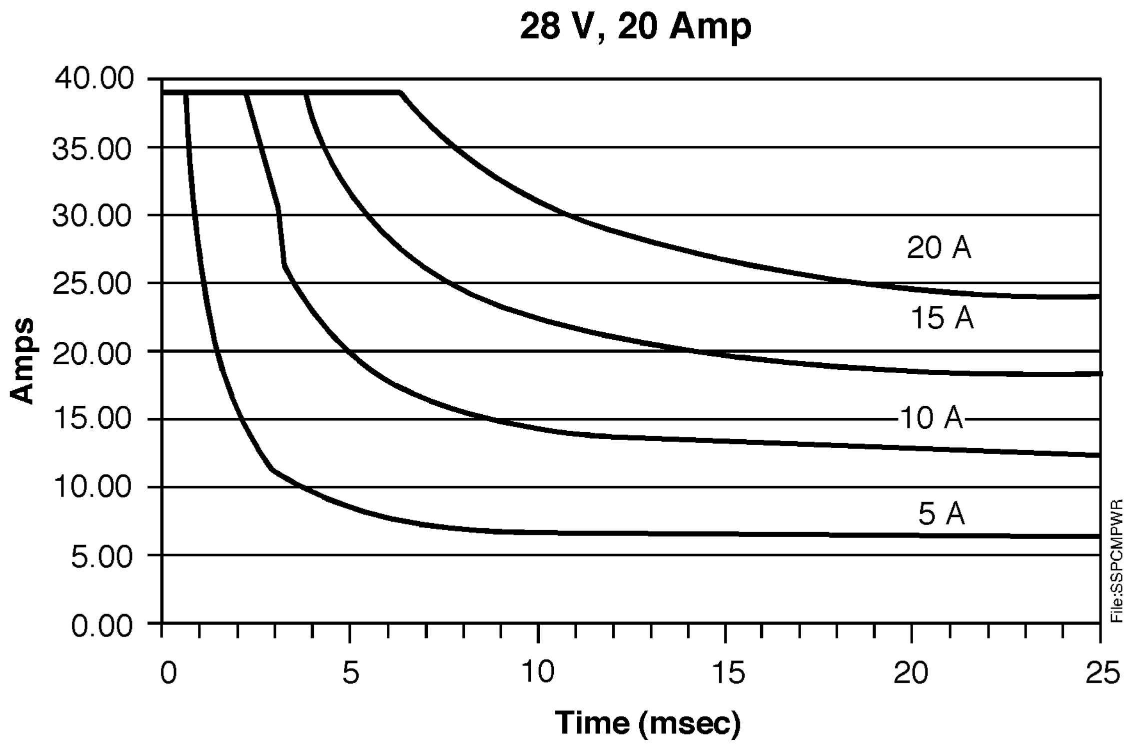


FIGURE 6-5 EXPRESS RACK POWER DISTRIBUTION DIAGRAM AND SSPCM INTERCONNECTIONS



NOTES:
1. Current limit region shown above is defined for a capacitor load charge. In a direct short condition the actual trip time is ½ of the values shown.
2. For a progressive short in which the change in current has a slow rise time, an absolute maximum current limit of 2.5 times the normal current limit is provided. The time to trip for this condition is dictated by the I^2 x t trip limit.
3. Final current limit is obtained within 100 µsecs and the initial current limit is a maximum of 2 times the final. Maximum 78 A ±20% (short circuit current).
4. The current limit is 39.0 A ±20 %.
5. The trip values for the long-duration portion of the trip curves are a nominal 120 % of range.

FIGURE 6-6 SSPCM TRIP CURVE

B. The SSPC will activate to a resistive load sized for the rated output current or a capacitive load of 50 µF/A of rated output current. The payload equipment shall be compatible with this specification.

C. Payload electrical power distribution circuitry shall be designed in accordance with NSTS 18798, JSC memo TA-92-038, and NASA SSP 30312G, Section B3.5.2, such that electrical faults do not damage EXPRESS Rack wiring nor present a hazard to the EXPRESS Rack, other ISS hardware items, other payloads, or crew.

Note: The 28 Vdc power and return wire must be sized to carry 24 A to the payload's first overload protection device. This maximum current considers two failures (incorrect setting of the SSPCM output to 20 A and a "Smart Short.")

D. Payloads that require multiple power inputs or more power than can be provided by a single power output may use more than one 28 Vdc output. The payload shall provide isolation (minimum of 1.0 megohm) of the 28 Vdc outputs such that the power and return lines from each 28 Vdc source are isolated from each other.

Note: 200 °C electrical wiring insulation will be used in the EXPRESS Rack and Shuttle middeck.

6.3 RIPPLE AND TRANSIENT SPIKE (REPETITIVE) LIMITS - SHUTTLE/MIDDECK

Ripple and transient spike limits for electrical power provided by the Shuttle/middeck at the indicated interfaces will not exceed the voltage values specified in the following paragraphs. The following information is actually controlled in the Middeck IDD.

6.3.1 In-Flight dc Power Bus Ripple at the Interface - Shuttle/Middeck

In-flight dc power bus ripple at the interface will not exceed:

A. 0.90 V peak-to-peak narrowband (30 Hz to 7 kHz) falling 10 dB per decade to 0.28 V peak-to-peak at 70 kHz, thereafter remaining constant to 400 MHz. The payload equipment shall be compatible with this specification.

On orbit, during the orbiter hydraulic circulation pump startup conditions (<300 ms), a sawtooth ripple voltage of 4 V peak-to-peak amplitude will appear on the 28 Vdc power bus at a frequency of 500 to 700 Hz. The payload equipment shall be compatible with this specification.

B. The momentary coincidence of two or more signals at any one frequency will not exceed the envelope defined as 1.6 V peak-to-peak (30 Hz to 7 kHz), falling 10 dB per decade to 0.5 V peak-to-peak at 70 kHz, thereafter remaining constant to 400 MHz. The payload equipment shall be compatible with this specification.

6.3.2 In-Flight dc Power Transient Spikes (Repetitive) - Shuttle/Middeck

In-flight dc power transient spikes (measured differential mode) will not exceed twice the line voltage relative to the line voltage for either positive or negative transients. The payload equipment shall be compatible with this specification.

6.3.3 Ground dc Power - Shuttle/Middeck

The following information is controlled in the Middeck IDD. If powered on the ground in the Shuttle (i.e., prelaunch and/or postlanding), the payload shall be compatible with the following ground dc power specifications.

A. The narrowband ripple voltage at the interface will not exceed an envelope with limits of 1.2 V peak-to-peak (30 Hz to 7 kHz), falling log-linear to 0.28 V peak-to-peak at 70 kHz, thereafter remaining constant to 400 MHz.

B. The momentary coincidence of two or more signals at any one frequency will not exceed an envelope with limits of 2 V peak-to-peak (30 Hz to 7 kHz), falling log-linear to 0.5 V peak-to-peak at 70 kHz, thereafter remaining constant to 400 MHz.

C. Transient spikes (measured common mode) will not exceed the impulse equivalent of 300 x 10-6 volt seconds above or below normal line voltage. Peak transient spikes will be limited to ±50 V from nominal bus voltage on the positive line, and ±30 V from nominal on the negative line. Rise and fall time will not be less than 1 μs.

6.3.4 Ac Power Characteristics - Shuttle/Middeck

Payloads using ac power in the Shuttle/middeck shall be compatible with the requirements in NSTS 21000-IDD-MDK, paragraph 7.3. Note that there is no ac power available in the EXPRESS Rack.

6.4 RIPPLE AND TRANSIENT SPIKES (REPETITIVE) LIMITS - ISS

Ripple limits for electrical power provided by the EXPRESS Rack SSPCM at the indicated interfaces will not exceed the voltage values shown in Figure 6-7. Payloads shall be compatible with these characteristics.

6.4.1 Startup Condition Spikes

Startup condition spikes for electrical power provided by the EXPRESS Rack SSPCM will not exceed the envelope shown in Figure 6-4. Payloads shall be compatible with these characteristics.

6.4.2 Differential Mode PARD (Noise/Ripple)

The differential mode Periodic and Random Deviation (PARD) will not exceed 1.0 volt peak-to-peak composite value for no load to full load over a measurable bandwidth from dc to 20 MHz. The payload shall be compatible with these characteristics.

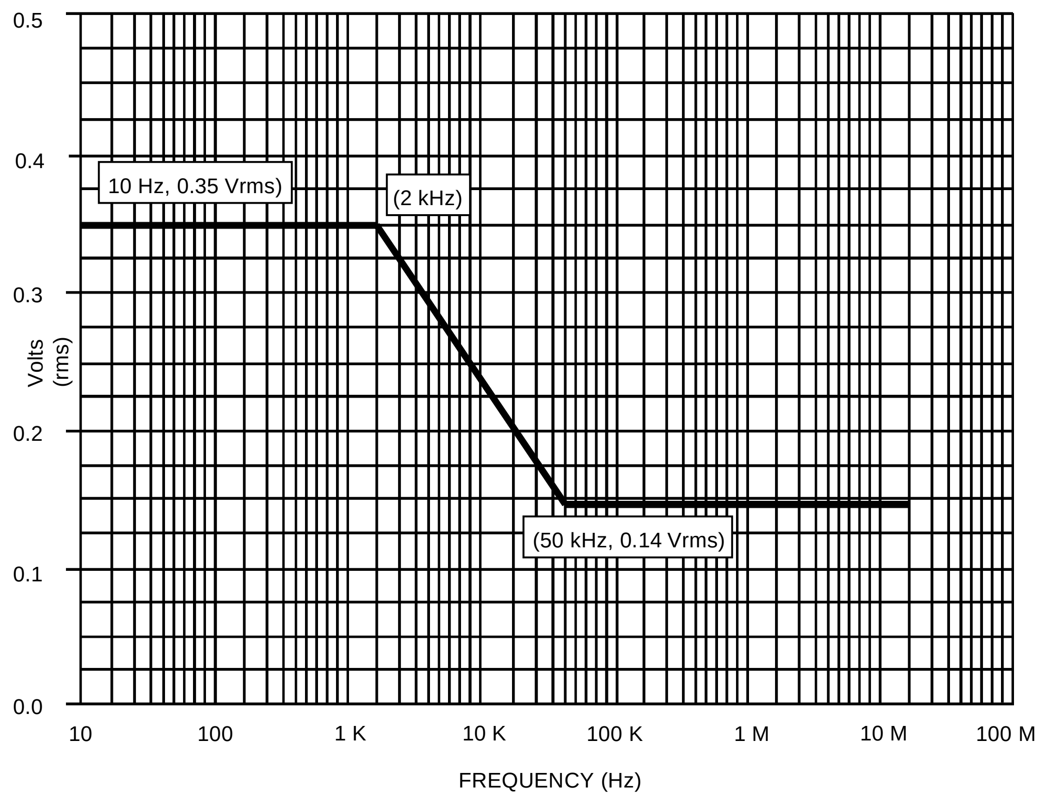


FIGURE 6-7 MAXIMUM RIPPLE VOLTAGE SPECTRAL COMPONENTS FOR 28 VDC INTERFACE (SSPCM OUTPUT)

6.5 LIMITATIONS ON EXPRESS RACK PAYLOAD UTILIZATION OF ELECTRICAL POWER

6.5.1 On-Orbit Transfer

Payloads requiring on-orbit transfer should be designed to withstand up to 30 minutes without ISS and/or Shuttle-supplied power.

6.5.2 EXPRESS Rack Payload Electrical Safety/Hazards

6.5.2.1 Batteries

Payloads shall meet the requirements for batteries, as specified in the NSTS 20793 and NSTS 1700.7 Addendum.

6.5.2.2 Safety-Critical Circuits

Safety-critical circuits are any electrical circuits that are used to control a hazard. For EXPRESS Rack payloads with safety-critical circuits, the following specific requirements will apply:

A. All EXPRESS Rack payload safety-critical circuits shall meet the redundancy requirements defined in NSTS 18798, memorandum ET12-90-115.

B. EXPRESS Rack payload safety-critical circuits controlling catastrophic hazards shall meet the margins defined in “C” below, for the conducted susceptibility limits specified in paragraph 7.3.1, and the radiated susceptibility limits specified in SSP 30237, paragraph 3.2.4.

C. Circuits implementing critical functions such that incorrect operations due to Electromagnetic Interference (EMI) could result in loss of life or loss of ISS shall be demonstrated to have an EMI safety margin of 6 dB by test or 20 dB by analysis. EMI safety margins for firing circuits of critical electroexplosive devices shall be demonstrated to be 20 dB by test or 34 dB by analysis.

6.5.2.3 Electrical Hazards

Electrical equipment other than bioinstrumentation equipment will incorporate the following controls as specified below:

A. If the exposure condition is below the threshold for shock (i.e., below maximum leakage current and voltage requirements as defined within this section), no controls are required. Non-patient equipment with internal voltages not exceeding 30 Vrms or dc nominal (32 Vrms or dc maximum) will contain potentials below the threshold for electrical shock.

B. If the exposure condition exceeds the threshold for shock, but is below the threshold of the let-go current profile (critical hazard) as defined in Table 6-II, two independent controls (e.g., a safety (green) wire, bonding, insulation, leakage current levels below maximum requirements) shall be provided such that no single failure, event, or environment can eliminate more than one control.

C. If the exposure condition exceeds both the threshold for shock and the threshold of the let-go current profile (catastrophic hazardous events) as defined in Table 6-II, three independent controls shall be provided such that no combination of two failures, events, or environments can eliminate more than two controls.

TABLE 6-II LET-GO CURRENT PROFILE
THRESHOLD VERSUS FREQUENCY

FREQUENCY (Hz)	MAXIMUM TOTAL PEAK CURRENT (ac + dc components combined) (milliamperes)
DC	40.0
15	8.5
2000	8.5
3000	13.5
4000	15.0
5000	16.5
6000	17.9
7000	19.4
8000	20.9
9000	22.5
10000	24.3
50000	24.3
(Based on 99.5 Percentile Rank of Adults	

D. If two dependent controls are provided, the physiological effect that a crewmember experiences as a result of the combinations of the highest internal voltage applied to or generated within the equipment and the frequency and waveform associated with a worst-case credible failure shall be below the threshold of the let-go current profile as defined in Table 6-II.

E. If it cannot be demonstrated that the hazard meets the conditions of paragraph A, B, or C above, three independent hazard controls shall be provided such that no combination of two failures, events, or environments can eliminate more than two controls.

Note: Guidelines for crew safety with respect to electrical hazards of bioinstrumentation devices are given in Appendix Y of JSC 20483, JSC Institutional Review Board Guidelines for Investigators Proposing Human Research for Space Flight and Related Activities.

6.5.3 Power Loss

Loss of ISS or EXPRESS Rack-supplied power to the EXPRESS Rack payload element during on-orbit operation will require reconfiguration of EXPRESS Rack power to restore power to the payload but shall not result in a hazardous condition.

6.5.3.1 Automatic Starting After Power Loss

Switches/controls shall be employed that prevent automatic starting after an overload-initiated shutdown.

6.5.4 Emergency Operational Modes

For emergency operational modes, the payloads shall be able to sustain a safe condition with permanent loss of power.

6.5.5 Payload Element Activation/Deactivation and Isolation

The payload shall provide means for its power activation/deactivation via crew control. This could be done by utilizing a switch or circuit breaker which can be activated either remotely (via ground command or laptop) or manually.

6.6 ELECTRICAL CONNECTORS

6.6.1 Connector Pins/Sockets

The powered side of a connector pair shall be terminated in sockets rather than pins.

6.6.2 Electrical Connector Mating/Demating (Unpowered)

Payload connectors shall not be mated or demated until voltages have been removed (dead-faced) from the powered side(s) of the connectors.

6.6.3 Electrical Connector Mating/Demating (Powered)

If paragraph 6.6.2 is not feasible, the payload shall comply with the requirements for mating/demating of powered connectors specified in NSTS 18798, MA2-99-170.

A. Payload connectors shall be specifically designed and approved for mating and demating in the existing environment under the loads being carried, or connectors must not be mated or demated until voltages have been removed (dead-faced) from the powered side(s) of the connectors.

B. Connector interfaces categorized as high-power connectors shall meet the following requirements (high-power connector interfaces are those that do not limit the short circuit outputs to 16 W or less or have an open-circuit output voltage of greater than 32 V). (Items (2), (3), and (4) apply only to payloads that generate voltages greater than 32 V):

(1) Each powered circuit shall have one verifiable upstream inhibit which removes voltage from the connector. The design shall provide for verification of the inhibit status at the time the inhibit is inserted.

(2) The powered side (upstream) connector shall have a grounded backshell.

(3) When mating/demating recessed connectors (e.g., connectors attached to equipment that will be remote from the crew such as back-of-the-rack when the connectors are mated/demated), a design feature for the grounding of the case shall be maintained while mating/demating the connector.

(4) Payloads that are reconfigured such that their fault bond is disturbed during mate/demate operations, shall require either redundant fault bonds to grounded structure or a post-installation test to verify a good fault bond has been established prior to payload power activation.

6.6.4 Electrical Connector Mismating Prevention

The design of electrical connectors shall make it physically incompatible to inadvertently reverse a connection or mate the wrong connectors if a hazardous condition can be created.

A. Payload’s GSE and on-orbit support equipment, wire harnesses, and connectors shall be designed such that blind connections or disconnections are not required to be made during payload installation, operation, removal, or maintenance on orbit unless the design includes scoop proof connectors or other protective features that prevent pin damage and/or inadvertent pin connections due to misalignment. The power and data connections at the rear of the ISIS drawers meet the second part of this requirement (i.e., providing protective features).

B. Payload equipment external plugs and receptacles (connectors), which when mismated or cross-connected may damage ISS-provided equipment, shall be selected and applied such that they cannot be mismated or cross-connected in the intended system as well as adjacent ISS systems. Although identification markings or labels are required, the use of identification alone is not sufficient to preclude mismating.

C. For all other payload connections, the use of combinations of identification, keying and clocking, and equipment test and checkout procedures shall be employed at the payload's discretion to minimize equipment risk while maximizing on-orbit operability.

D. All cables shall be uniquely labeled on each end as to where it connects and the cable labeled in the center as to its purpose.

6.6.5 Mechanical Protection

Payload connectors shall be selected and applied such that they have sufficient mechanical protection to minimize inadvertent crewmember contact with exposed electrical contacts.

6.6.6 Current Draw Labeling

Sub-rack PD hardware shall be labeled to identify current draw as identified in Table 6-III.

TABLE 6-III PD CURRENT DRAW LABELING REQUIREMENTS

ITEM	REQUIREMENT	REMARKS/NOTES
A	Each EXPRESS Rack payload must have a label affixed to the front panel in the area of and/or close to the power interface connector identifying the current dra value which the SSPCM will be set.	The SSPCM current dra value settings are 5 A, 10 A, 15 A, and 20 A.
B	Current draw labels are required for each individual interface to the EXPRESS Rack power system.	
C	ISIS drawers must have the current draw label affixed to the front panel.	
D	Current draw label must be configured as a warning label per the requirements of Appendix E.	Labels are available and identified in decal catalog.

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SECTION 7, ELECTROMAGNETIC COMPATIBILITY (EMC)

7.1 CIRCUIT EMC CLASSIFICATIONS

Circuit EMC classifications are defined in Table 7-I. As a design goal, EXPRESS Rack payload wiring on the payload side of the interface should meet the requirements of Table 7-II, or utilize equivalent shielding to minimize EMI affects. In any event, the EXPRESS Rack payload must comply with the radiated and conducted EMC interference requirements of paragraph 7.3.

7.2 SHUTTLE-PRODUCED INTERFERENCE ENVIRONMENT

7.2.1 Conducted Interference

The payload shall be compatible with the requirements stated in paragraph 6.3, "Ripple and Transient Spike (Repetitive) Limits."

7.2.2 Radiated Interference - Shuttle/Middeck

The Shuttle-produced radiated fields environment on which payload design shall be based is limited as follows:

A. Electric fields are defined in Figures 7-1 and 7-2 for unintentional emissions and Figure 7-3 for intentional emissions (e.g., radio transmission, etc.).

B. The generated ac magnetic fields will be limited to less than 140 dB above 1 pT (30 Hz to 2 kHz), falling 40 dB per decade to 50 kHz.

C. These levels will be considered when evaluating the possibility of operating radio frequency receiving equipment or electronic field sensing equipment.

D. The lightning-produced magnetic fields in the crew compartment for vehicles in flight will be limited to a peak level of 3 A/m; for vehicles on the ground protected by facility or other structures, the peak level will be limited to 5 A/m; and for vehicles on the ground not protected by facility or other structures, the peak level will be limited to 10 A/m. The rise to peak value is 2 µs, and the fall to zero value is 100 µs. The payload shall be designed so that a failure due to a lightning strike shall not propagate to the Shuttle.

E. The design of the Shuttle will preclude any Electrostatic Discharges (ESD).

TABLE 7-I CIRCUIT EMC CLASSIFICATIONS

FREQ. OF RISE AND/OR FALL TIME	SOURCE IMPEDANCE (ohms)	LOAD IMPEDANCE (ohms)	VOLTAGE OR SENSITIIVITY	CIRCUIT CLASSIFI-CATION[4]	WIRE TYPE REQD	SHIELD GROUNDING REQMTS
Analog Alternating or Direct Current	<100	100 - 600 k 0 - 200 0 - 200	>100 Mv to≤6 V >6 V to ≤40 V >40 V	ML HO EO	TWS TW TW	SPG[2] None None
	≤2.5 k	100 - 600 k >600 k	≤100 mV	ML	TWS TWDS	SPG SPG
	<100	≥200 ≥200 ≥200	100 mV t ≤6 V >6 V to ≤40 V >40 V	ML HO EO	TWS TW TW	SPG None None
≤50 kHz or Ris and Fall Tim ≥ 10 µs	<100	≥10 k 0 - 200 0 - 200	≤6 V >6 V TO ≤40 >40 V	ML HO EO	TWS TW TW	SPG None None
	<2.5 k	100 - 600 k >600 k	≤100 MV	ML	TWS TWDS	SPG SPG
	≥200	>200 >200 >200	>100 MV TO ≤6 V >6 V to ≤40 V >40 V	ML HO EO	TWS TW TW	SPG[2] None None
>50 kHz or Rise and Fall Tim ≤10 µs ≤1.024 MHz	All	All All	≤100 mV >100 mV t ≤6 V	RF RF	TWDS[1] TWS[1]	MPG MPG
		<1000 ≥1000	>6 V	RF	TWS[1] TWDS	MPG MPG
>1.024 MHz	All	All	All	RF	COAX	MPG
Video (RS 170A)	75 ± 5	75 ± 5		RF	TWS	MPG[3]

Symbols Used

AF	- Audio Frequency	TSP	- Twisted Shielded Pair	mV	- Millivolts dc)
Coax	- Coaxial	TW	- Twisted	µs	- microseconds
k	- Kilo	TWDS	- Twisted Double Shielded	<	- less than
kHz	- Kilohertz	TWS	- Twisted Shielded	≤	- less than or equal to
MHz	- Megahertz	V	- Volts (dc)	>	- greater than
MPG	- Multiple Point Ground			≥	- greater than or equal to
RF	- Radio Frequency				
SPG	- Single Point Ground				

NOTES:

1. If the capacitance per foot is critical, controlled-impedance wiring, special-shielded-twisted pair cables (nominal 75 ohms) should be used.
2. If circuit is balanced by transformer, differential or optical, the shield shall be multi-point grounded to structure.
3. Distance between shield grounds shall not exceed 18 m.
4. The symbols ML, HO, EO are arbitrary nomenclature to define circuit classification and have no meaning.

7.2.2.1 Shuttle-Produced Wireless Crew Communication System (WCCS) Radiated Electric Fields

The WCCS is used on Shuttle flights and is primarily located in the Shuttle flight deck and middeck. WCCS operational frequencies are between 338.0 MHz and 392.0 MHz in the crew compartment. The maximum radiated field intensity for the WCCS is 1.0 V/m at

TABLE 7-II EXPRESS RACK PAYLOADS EDGE-TO-EDGE BUNDLE SEPARATION REQUIREMENTS[4]

BUNDLE	ROUTED PARALLEL TO BUNDLE	SEPARATION[1,2] [in inches for parallel runs of D (feet)]			
		$1 > D$	$1 \le D < 3$	$3 \le D < 5$	$D \ge 5$
ML	HO	0	1.0	2.0	4.0
	EO	0	1.5	3.0	6.0
	RF	0	2.5	5.0	10.0
HO	EO	0	0.5	1.0	2.0
	RF	0	1.5	3.0	6.0
EO	RF	0	1.0	2.0	4.0

NOTES:

1. Design goal to keep 3 inches of separation.
2. Separation values are in inches.
3. "HO" and "EO" referred to switched (on and off) power lines.
4. This table is applicable to both Shuttle-located and ISS-located hardware items.

1.0 m away from the source. (Also reference NSTS 21000-IDD-MDK, paragraphs 7.2.2 and 7.3.1.3). EXPRESS Rack payloads when exposed to this environment shall not result in a hazardous condition.

7.3 ELECTROMAGNETIC COMPATIBILITY

Payloads that are powered during transportation on board the Shuttle must meet the EMC requirements of paragraphs 7.2 and 7.4. EMC requirements for ISS compatibility are as follows.

7.3.1 Emission and Susceptibility Limits and Test Methods

These requirements apply to payload electronic, electrical, electromechanical equipment, and subsystems emissions and susceptibilities. Approval of design procedures and techniques does not relieve the payload of the responsibility of meeting the emission test limits. Tests shall be performed and data submitted for conducted and radiated susceptibility. Conducted and radiated susceptibility test data shall be evaluated against the limits of this document. The threshold of susceptibility shall be determined for equipment unable to meet the susceptibility test limits. Compliance with the susceptibility limits is not required by the ERO; however, each PD should consult the Research Program Office for additional guidance

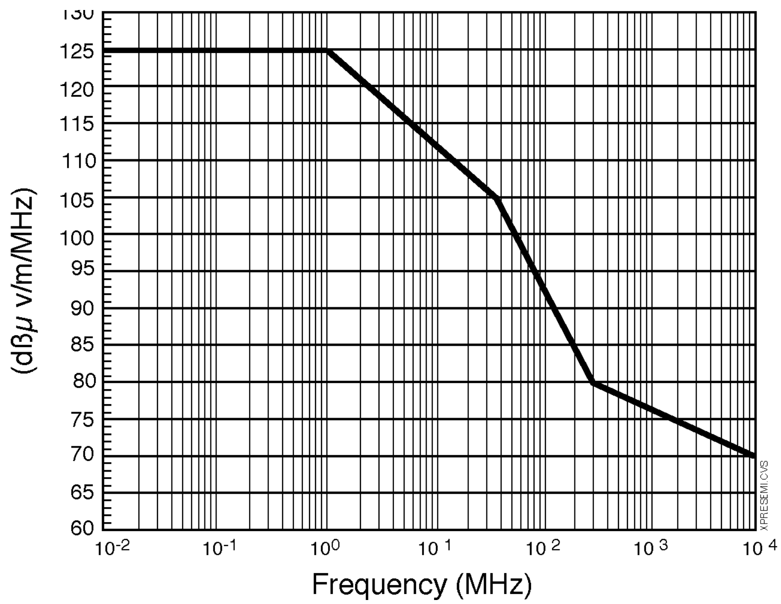


FIGURE 7-1 SHUTTLE-PRODUCED RADIATED BROADBAND EMISSIONS, UNINTENTIONAL (CONTROLLED IN THE MIDDECK IDD)

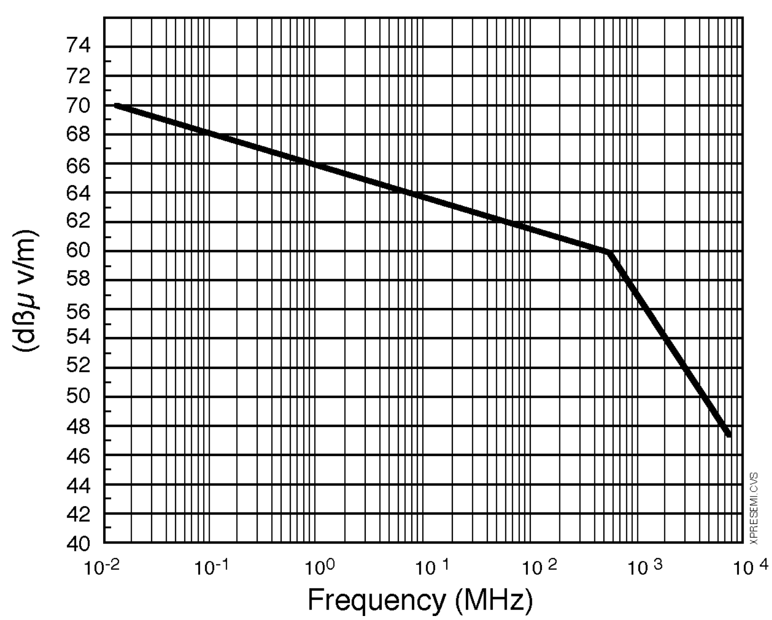


FIGURE 7-2 SHUTTLE-PRODUCED RADIATED NARROWBAND EMISSIONS, UNINTENTIONAL (CONTROLLED IN THE MIDDECK IDD)

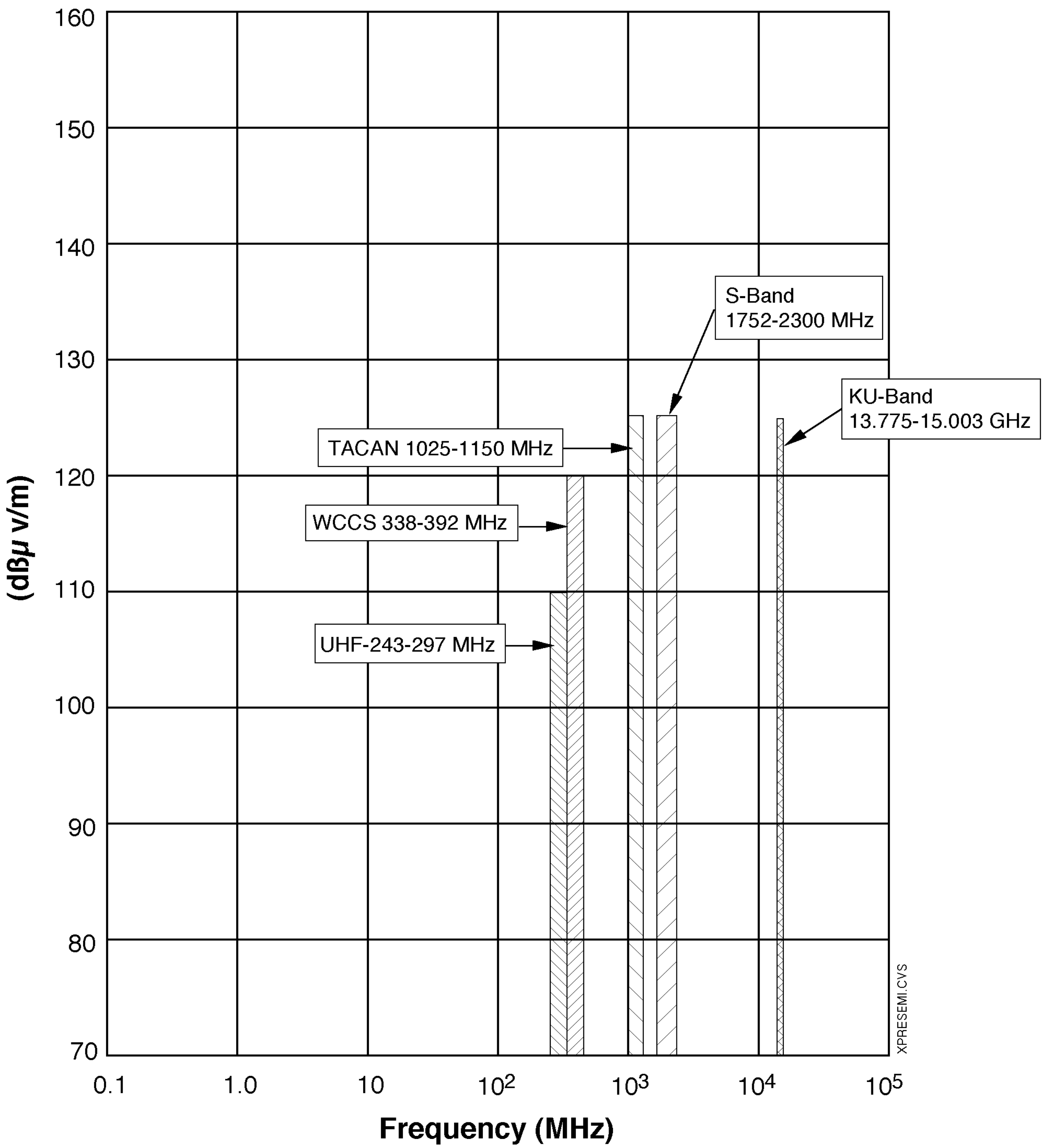


FIGURE 7-3 SHUTTLE-PRODUCED RADIATED NARROWBAND EMISSIONS, INTENTIONAL (CONTROLLED IN THE MIDDECK IDD)

regarding compliance for susceptibility. The data is for complement-level payload risk evaluation purposes.

Testing of the equipment to ensure compliance to the requirements of this document shall be performed using the test methods given in SSP 30238, Space Station Electromagnetic Techniques, and as amended in SSP 52000-PVP-ERP.

7.3.1.1 Compatibility

The payload, designed in accordance with the EMC requirements, shall not malfunction, and performance shall not be degraded during conductive and radiated emission EMI testing. Payloads that do not meet the conductive and radiated susceptibility test limits shall not produce an unsafe condition or one that could result in damage to ISS equipment or payload hardware.

7.3.1.2 Applicability

These requirements are designed to provide complete EMC/EMI design requirements for payload equipment requiring a +28 Vdc source.

7.3.1.3 Conducted Emissions

Wiring between two or more Orbital Replacement Units (ORU) is exempt from the conducted emissions test requirements provided the specific ORUs are tested as a single unit. Wiring external to the group of ORUs tested as a unit shall meet the test limit requirements of this document.

7.3.1.3.1 CE01, Conducted Emissions

CE01 applies to dc input power leads, 30 Hz to 15 kHz.

CE01 is applicable only for narrowband emissions between 30 Hz and 15 kHz on dc leads which obtain power from or provide power to other equipment, distribution panels, or subsystems.

7.3.1.3.2 CE01 Limits

Payload narrowband conducted emissions in excess of the values shown below shall not appear on dc input power leads. The emissions limit shown in Table 7-III is for equipment drawing 1 A or less. For equipment drawing more than 1 A, the limit, in decibels shown below shall be raised by 20 log I, where I equals the total dc current used by the Equipment Under Test (EUT).

TABLE 7-III CE01 LIMITS

FREQUENCY	EMISSIONS
30 Hz - 200 Hz	110 dB above 1 μA
200 Hz - 15 kHz	Decreasing log-linearly with increasing frequency from 110 dB to 74 dB above 1 μA

7.3.1.3.3 CE03, Conducted Emissions

CE03 applies to dc input power leads.

CE03 is applicable only for narrowband emissions between 15 kHz and 50 MHz on dc leads which obtain power from other sources or provide power to other equipment, distribution panels, or subsystems.

7.3.1.3.4 CE03 Limits

Payload narrowband conducted emissions in excess of the values shown in Table 7-IV shall not appear on dc input power leads. The limit shown in Table 7-IV is for equipment drawing 1 A or less. For equipment drawing more than 1 A, the limit shown in Table 7-IV shall be raised 20 log I, where I equals the total dc current used by the EUT.

TABLE 7-IV CE03 LIMITS

FREQUENCY	EMISSIONS
15 kHz - 500 kHz	Decreasing log-linearly with increasing frequency from 74 dB to 45 dB above 1 μA
500 kHz - 50 MHz	45 dB above 1 μA

7.3.1.3.5 CE07, Conducted Emissions

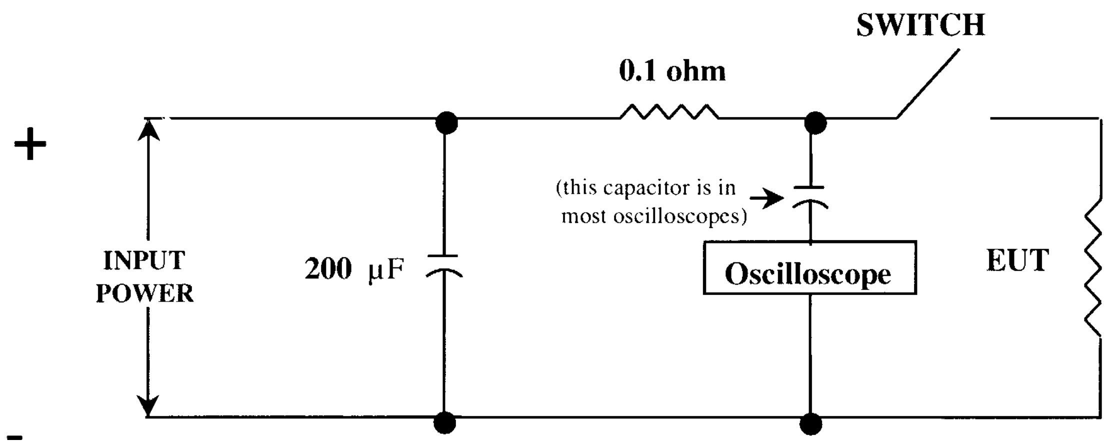
CE07 applies to dc input power leads, spikes, and time domain transients. CE07 is applicable for all 28 Vdc input power leads.

7.3.1.3.6 CE07 Limits

Payload CE07 on/off and operating mode switching transients shall not exceed the envelope defined by the values listed in Table 7-V. Repetitive on/off and mode switching transients shall not occur more frequently than every 100 ms. The payload shall use the Line Impedance Simulation Network (LISN) shown in Figure 7-3A for CE07 testing.

TABLE 7-V CE07 LIMITS

TIME (μsec)	PERCENTAGE OF NOMINAL LINE VOLTAGE
0.1 - 10	±50 percent
10 - 50	Decreasing log-linearly with increasing time from ±50 percent to ±20 percent
50 - 1000	Decreasing log-linearly with increasing time from ±20 percent to ±5 percent



NOTE: Input power leads from the laboratory supply to the LISN must be no longer than 2 feet and a minimum of 12 AWG.

FIGURE 7-3A CE07 LISN

7.3.1.4 Conducted Susceptibility

7.3.1.4.1 CS01, Conducted Susceptibility

CS01 applies to dc input power leads in the frequency range of 30 Hz to 50 kHz. CS01 is applicable to payload equipment using 28 Vdc input power.

7.3.1.4.2 CS01 Limits

Payloads shall not produce an unsafe condition or one that could result in damage to ISS equipment or payload hardware when subjected to electromagnetic energy injected onto its power leads less than or equal to the values as shown in Table 7-VI. The requirement is also considered met when the audio power source specified in SSP 30238 adjusted to

TABLE 7-VI CS01 LIMITS

FREQUENCY	VOLTAGE
30 Hz - 2 kHz	0.7 Vrms
2 kHz - 50 kHz	Decreasing log-linearly from 0.7 Vrms at 2 kHz to 0.28 Vrms at 50 kHz

dissipate 50 W in a 0.5-ohm load cannot develop the required voltage at the EUT power input terminals, and the EUT is not susceptible to the output of the signal source.

7.3.1.4.3 CS02, Conducted Susceptibility

CS02 applies to dc power leads in the frequency range of 50 kHz to 50 MHz. CS02 is applicable to payload equipment using 28 Vdc input power.

7.3.1.4.4 CS02 Limits

Payloads shall not produce an unsafe condition or one that could result in damage to ISS equipment or payload hardware when subjected to 0.28 Vrms from a 50-ohm source. The test signal shall be applied to the equipment power line near the equipment input terminals. The requirement is also considered met under the following condition: when a 1-W source of 50-ohm impedance cannot develop the required voltage at the EUT power input terminals, and the EUT is not susceptible to the output of the signal source.

7.3.1.4.5 CS06, Conducted Susceptibility

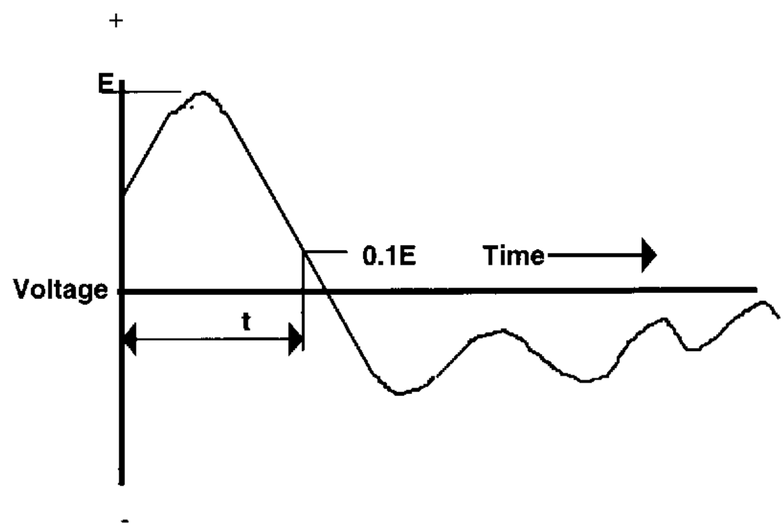
CS06 defines transients to be applied to 28 Vdc power leads for test purposes. CS06 is applicable to all payload equipment using 28 Vdc power.

7.3.1.4.6 CS06 Limits

Payloads shall not produce an unsafe condition or one that could result in damage to ISS equipment or payload hardware when the test spikes, each having the waveform shown on Figure 7-4, are applied sequentially to the dc power input leads. The values of E and t are given below. Each spike shall be superimposed on the power line voltage waveform.

A. Spike #1 E = ± one times the nominal line voltage, t = 10 microseconds ± 20 percent

B. Spike #2 E = ± one times the nominal line voltage, t = 0.15 microseconds ± 20 percent



**The EUT will be subjected to the spike(s)
With the waveform shown and with the specified voltage(s) and pulsewidth(s)**

Spike #1 E = ± One times the nominal line voltage, t = 10 microseconds ± 20 percent.
Spike #2 E = ± One times the nominal line voltage, t = 0.15 microseconds ± 20 percent.

FIGURE 7-4 CS06 AND RS02 PAYLOAD EQUIPMENT LIMIT

7.3.1.5 Radiated Emissions

7.3.1.5.1 RE02, Radiated Emissions

Electric field, 14 kHz to 10 GHz, 13.5 to 15.5 GHz (narrowband).

7.3.1.5.2 Applicability

RE02 is applicable for radiated emissions from equipment and subsystems, cables (including control, pulse, Interface (I/F), power and antenna transmission lines) and interconnecting wiring of the EUT; for narrowband emissions, it applies at the fundamental frequencies and all spurious emissions including harmonics, but does not apply for radiation from antennas. This requirement is applicable for narrowband emissions from 14 kHz to 10 GHz, 13.5 to 15.5 GHz.

7.3.1.5.3 RE02 Limits

Payload E-field emissions shall not be radiated in excess of those specified in the following paragraph. Above 30 MHz, the limits shall be met for both horizontally and vertically polarized waves. Measurement shall be made in the peak detector mode.

7.3.1.5.4 Narrowband Electric Field Emissions

Payload narrowband E-field emissions shall not be radiated in excess of the following values as shown in Table 7-VII at the required test distance, 1 m.

TABLE 7-VII RE02 LIMITS

FREQUENCY	EMISSIONS
14 kHz - 10 MHz	56 dB µV per meter
10 MHz - 259 MHz	Increasing log-linearly with increasing frequency from 56 to 86 dB µV per meter (16 dB per decade)
259 MHz - 10 GHz	Increasing log-linearly with increasing frequency from 46 to 72 dB µV per meter (16 dB per decade)
13.5 GHz - 15.5 GHz	76 dB µV per meter

7.3.1.6 Radiated Susceptibility

7.3.1.6.1 RS02, Radiated Susceptibility

Magnetic induction field.

7.3.1.6.2 Applicability

RS02 is applicable for all equipment and subsystems. These susceptibility signals are electromagnetically coupled into the equipment and/or subsystem wiring.

7.3.1.6.3 RS02 Limits

Payloads shall not produce an unsafe condition or one that could result in damage to ISS equipment or payload hardware when subjected sequentially to the test spikes, each having the waveform shown in Figure 7-4, with the values of E and t as given below:

A. Spike #1 E = ± one times the nominal line voltage, t = 10 microseconds ±20 percent.

B. Spike #2 E = ± one times the nominal line voltage, t = 0.15 microseconds ±20 percent.

Power input and output leads are exempt from this test.

7.3.1.7 RS03, Radiated Susceptibility

Electric field, 14 kHz to 20 GHz.

7.3.1.7.1 Applicability

RS03 is applicable for all equipment and subsystems between 14 kHz and 20 GHz. Above 10 GHz, this requirement applies only at specific frequencies and magnitudes known to be present at the ISS. Below 10 GHz, this requirement is increased only at specific frequencies and amplitudes known to be present at the ISS. Module shielding effectiveness can be used to limit the levels applied.

7.3.1.7.2 RS03 Limits

Payloads shall not produce an unsafe condition or one that could result in damage to ISS equipment or payload hardware when subjected to the radiated electric fields less than or equal to those specified herein. Above 30 MHz, the requirement shall be met for both horizontally and vertically polarized waves. As a minimum, the levels in Table 7-VIII apply at either the specific frequencies stated or across the ranges stated:

TABLE 7-VIII RS03 LIMITS

FREQUENCY/RANGE	RADIATED ELECTRIC FIELD LEVEL
14 kHz - 400 MHz	5 V/m
400 MHz - 450 MHz	30 V/m
450 MHz - 1 GHz	5 V/m
1 GHz - 5 GHz	25 V/m
5 GHz - 6 GHz	60 V/m
6 GHz - 10 GHz	20 V/m
13.7 GHz - 15.2 GHz	25 V/m

7.3.2 Electrostatic Discharge

7.3.2.1 ESD Compatibility

Unpowered PD electrical equipment and components shall either fail safe or not be damaged by ESD equal to or less than 4,000 V to the case or any pin-on external connectors, or incorporate adequate protection measures into the hardware design to ensure the unpowered PD electrical equipment is not damaged during ground and on-orbit installation activities. Protection measures will include at a minimum protective caps/covers, handling procedures and ESD sensitive identification labels. These voltages are the result of charges accumulated and discharged from ground personnel or crewmembers during equipment installation or removal.

7.3.2.2 ESD Labeling

PD electrical equipment that may be damaged by ESD between 4,000 and 15,000 V shall have a label affixed to the case in a location clearly visible in the installed position and shall be in accordance with MIL-STD-1686.

7.3.2.3 Corona

Electrical and electronic subsystems, equipment, and systems shall be designed to preclude damaging or destructive corona in its operating environment.

Guidance for meeting the corona requirement is found in MSFC-STD-531, High Voltage Design Criteria. For payloads operating in a pressurized module, this requirement can be verified by the absence of corona during functional testing, provided all operations can be verified at ground level. If any payload operates in an unpressurized environment during ascent or descent, further evaluation is required.

7.3.2.4 Lightning

The lightning-produced magnetic fields for payloads that are transported in the MPLM will be limited to a peak level of 10 A/m. The rise to peak value is 2 μ-sec and the fall to zero value is 100 μ-sec. Payloads shall be designed so that a failure due to a lightning strike will not propagate to the shuttle or the ISS.

7.4 PAYLOAD-PRODUCED INTERFERENCE ENVIRONMENT - SHUTTLE

7.4.1 Payload-Produced Conducted Noise - Shuttle

The payload-generated conducted emission limits, applicable to all dc power interfaces, is as follows:

A. The power line conducted emissions in the frequency domain shall be limited to the levels indicated in Figure 7-5, and the steady-state ripple voltage in the time domain shall not exceed 28.45 V or drop below 27.55 V, starting at approximately 1 sec after the transient.

B. The cargo-generated transients produced on dc power lines by switching or other operations shall not exceed the limits defined in Figure 7-6 when fed from a source

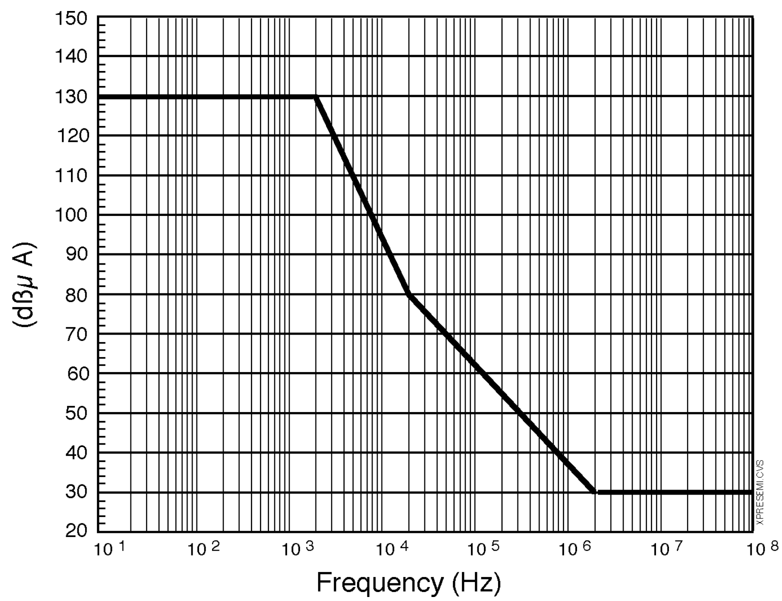


FIGURE 7-5 PAYLOAD ALLOWABLE-CONDUCTED NARROWBAND EMISSIONS FOR SHUTTLE (CONTROLLED IN MIDDECK IDD)

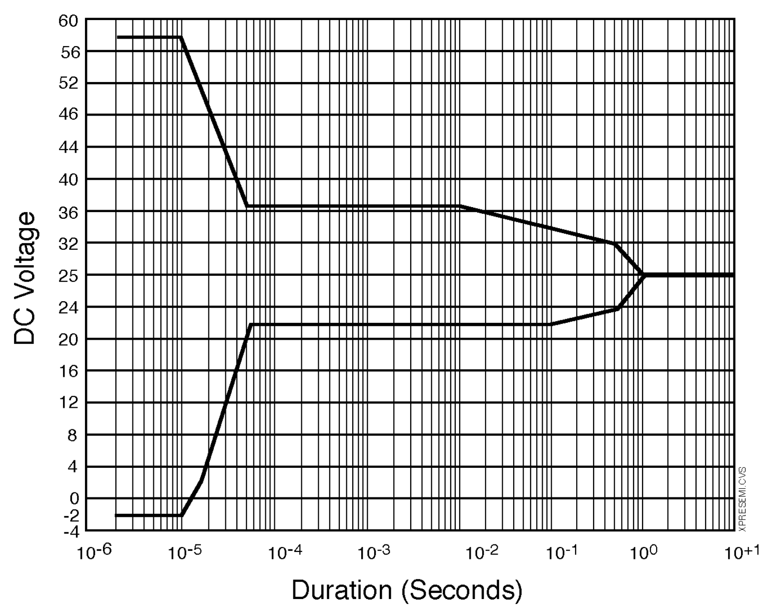


FIGURE 7-6 ENVELOPE OF PAYLOAD TRANSIENT SPIKES ON DC POWER BUSES FOR NORMAL ELECTRICAL SYSTEM OPERATION SHUTTLE (CONTROLLED IN THE MIDDECK IDD)

impedance close to, but not less than, the values defined in Figures 8.3.1-4 and 8.3.1-5 of NSTS 21000-IDD-MDK. (The use of a battery cart is preferable to regulated dc power supplies). Each non-overlapping transient is considered independent of prior or post-transients.

C. Rise and fall times for (B) above shall be greater than 1.0 μs.

7.4.2 Payload-Produced Radiated Fields - Shuttle

The payload-produced radiated fields must be limited as follows:

A. The unintentional radiated electric fields shall not exceed the levels defined in Figures 7-7 and 7-8.

B. The generated dc magnetic fields shall not exceed 170 dBpT at a distance of 1.0 m from any payload equipment. This limit applies to electromagnetic and permanent magnetic devices. The generated ac magnetic fields (applies at a distance of 1 m from any payload equipment) shall not exceed 130 dB above 1 pT (30 Hz to 2 kHz) falling 40 dB per decade to 50 kHz.

C. Electrostatic discharges shall not occur within the EXPRESS Rack payload other than those isolated from the gaseous environment (hydrogen-oxygen mixture) and shielded by the payload design to satisfy the requirements of subparagraph “A” above.

D. Allowable levels of radiation from EXPRESS Rack payload or payload transmitter systems shall be limited as shown in Figure 7-9. These limits shall apply 1 m from window-mounted antennas.

7.4.3 Magnetic Fields for EXPRESS Rack Payloads in the ISS

7.4.3.1 Alternating Current (ac) Magnetic Fields for EXPRESS Rack Payloads in the ISS

The generated ac magnetic fields, measured at a distance of 2.76 in (7 cm) from any equipment, shall not exceed 140 dB above 1 pT for a frequency at 30 Hz, then falling 26.5 dB per decade to 3.5 kHz, and 85 dB for the frequencies ranging from 3.5 kHz to 50 kHz. Test shall be performed using the MIL-STD-462D RE101 method as modified in SSP 52000-PVP-ERP.

7.4.3.2 Direct Current (dc) Magnetic Fields for EXPRESS Rack Payloads in the ISS

The generated dc magnetic fields shall not exceed 170 dBpT at a distance of 2.76 in (7 cm) from any equipment. This requirement applies to intentional electromagnetic and permanent magnetic devices.

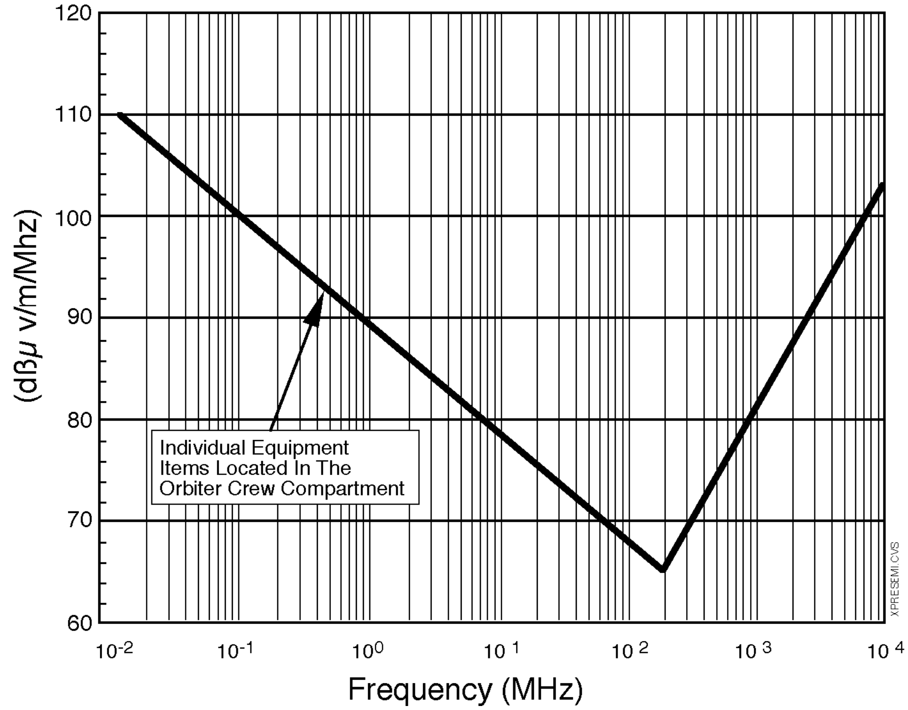


FIGURE 7-7 PAYLOAD ALLOWABLE UNINTENTIONAL RADIATED BROADBAND EMISSIONS FOR SHUTTLE (CONTROLLED IN THE MIDDECK IDD)

7.5 AVIONICS ELECTRICAL COMPATIBILITY - SHUTTLE AND ISS

7.5.1 Electrical Bonding

The payload-to-EXPRESS Rack electrical bonding interface shall be electrically bonded to provide homogeneous electrical characteristics. All electrical and mechanical elements shall be securely bonded to structure in accordance with SSP 30245. Four classes of bonds are applicable to either middeck, EXPRESS Rack, or both: Classes C, H, R, and S. These bond classes are defined in the following paragraphs. These definitions will be used in further discussion on bonding requirements.

A. Fault Current Bond - Class C

All payload elements using EXPRESS Rack facility power shall have mechanically secure electrical connections to the EXPRESS Rack structure capable of carrying the maximum return fault current [see paragraph 6.2.3 (Current Limiting)].

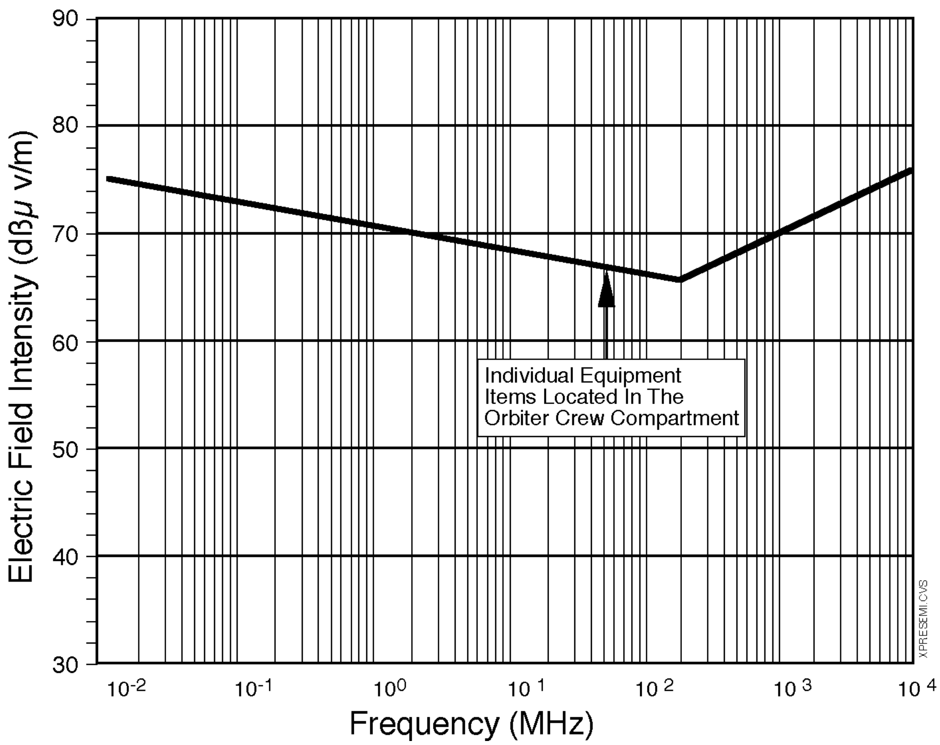


FIGURE 7-8 PAYLOAD ALLOWABLE UNINTENTIONAL RADIATED NARROW-BAND EMISSIONS FOR SHUTTLE (CONTROLLED IN MIDDECK IDD)

B. Shock Hazard - Class H

Exposed conducting frames or parts of electrical or electronic equipment shall have a low resistance bond of less than 0.1 ohm to conducting structure. If the equipment design includes a ground terminal or pin which is internally connected to exposed parts, a ground connection to the terminal or pin shall be provided.

C. Radio Frequency (RF) Bond - Class R

Payload elements containing electrical circuits which generate radio frequencies or circuits which are susceptible to radio frequency interference may require a low impedance path to structure in order to comply with EMC requirements. The dc resistance of the Class R bond between the payload and the EXPRESS Rack interface shall be less than 2.5 milliohms for each joint.

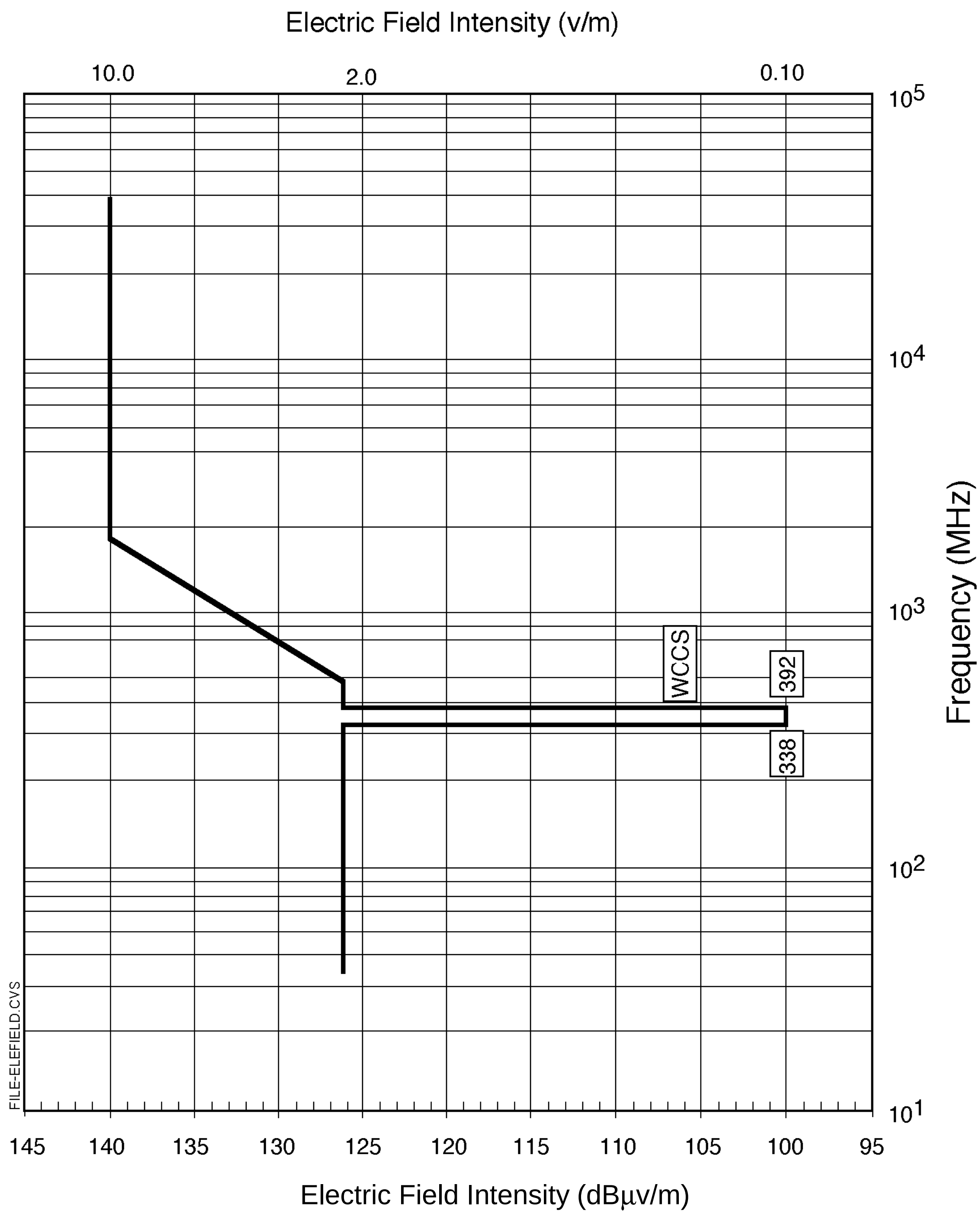


FIGURE 7-9 ALLOWABLE INTENTIONAL ELECTRIC FIELD STRENGTH IN THE SHUTTLE CREW COMPARTMENT (CONTROLLED IN THE MIDDECK)

D. Static Bond - Class S

All conducting items subject to triboelectric (frictional) or any other charging mechanism shall have a mechanically secure electrical connection to the payload element structure. The resistance of this connection shall be less than 1 ohm for each joint.

7.5.1.1 Electrical Bonding of Payload Hardware

Equipment which generates and/or is susceptible to RF interference shall have a Class R bond (see note below). In addition, the metallic shells of all external electrical connectors shall be electrically bonded to the payload equipment case or the payload equipment bulkhead mount with a dc resistance of less than 2.5 milliohms per joint.

Note: Insert payloads are inserted into lockers (either ISS or middeck) without provisions for a mated surface bond. If inserts meet their EMI/EMC requirements bonded solely through their interface cables, the Class H bond generated by the interface cables will be acceptable in place of the Class R bond.

Wire harness shields external to equipment, requiring grounding at the payload equipment, shall have provisions for grounding the shields to the payload equipment through the harness connector backshell or for carrying single point grounded shields through the connector pins.

7.5.1.1.1 Redundant Bond Paths

Payloads that have voltages greater than 32 Vrms or 32 Vdc shall have redundant bond paths (see note below) as specified in NSTS 18798, letter MA2-99-142.

Note: The data cable shield may serve as the second return path for insert payloads.

7.5.1.2 Electrical Bonding of Payload Structures

7.5.1.2.1 Payload-to-EXPRESS Rack Main Bond

Accommodations available within the EXPRESS Rack to provide bonding surfaces/ paths for the payload user are detailed below. The primary power connector bond provides a class C, H, and S bond path when the payload’s power connector ground pin is bonded to the payload chassis. The preferred method for RF bonding (Class R) is the mated/faying surface bond. When this is not possible, the payload may use a RF bond strap as described below.

7.5.1.2.1.1 Primary Payload Power Connector Bond

The primary payload bond path is through the EXPRESS Rack-to-payload power connector interface. The bond path shall be accomplished by a single 12-American Wire Gauge (AWG) wire in the power connector capable of carrying a current of 24 A. For payloads requiring Shuttle middeck power, a 12 AWG wire/pin capable of carrying a maximum current of 33 A is required when interfacing with the middeck 20-A service connectors.

EXPRESS Rack payload bonds shall meet the appropriate bond class requirements of paragraph 7.5.1, “Electrical Bonding,” and EXPRESS Rack payloads and shall have less than or equal to 2.5 milliohms, at each junction of the fault bond interface. The dc resistance from the payload’s power connector ground pin (pin D for MDLs or pin 12 for ISIS drawers) to the payload’s external conductive chassis shall not exceed 50 milliohms.

7.5.1.2.1.2 Payload-to-EXPRESS Rack Bond Strap

If this method is chosen, the payload-to-EXPRESS Rack bond strap shall be payload provided and shall be designed to be connected between EXPRESS Rack structure and the payload’s ground attachment provisions. This bond shall meet the requirements of paragraph 7.5.1, “Electrical Bonding,” and shall have less than or equal to 2.5 milliohms (Class R) at each junction of the fault current interface. There are only certain places to attach this strap on the EXPRESS Rack (on each of the ISPR front posts with #10 inserts), so to properly utilize this connection the rack integrator must be contacted.

7.5.1.2.1.3 Payload-to-EXPRESS Rack Mated Surface Bond

Removable bonds are those that are expected to be mated or demated as part of the Shuttle or EXPRESS Rack interface. The payload-to-EXPRESS Rack mated surface bond (defined as the payload, adapter plate, or MDL surface that attaches to the EXPRESS Rack backplate) is a removable bond and shall be nickel or nickel plated per SSP 30245. The maximum resistance between the mated surfaces of the bond connection (connector to mounting base, mounting base to EXPRESS Rack, or when applicable, mounting base to payload) shall be less than or equal to 2.5 milliohms (Class R) at each junction of the fault current bond interface.

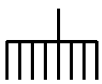
All aluminum surfaces used for permanent bonding in the payload shall be originally cleaned to bare metal, then chemically filmed per MIL-C-5541, Class 3 (gold alodine 1200LN9368 or equivalent) or nickel plated using methods in MIL-C-26074, Class 4, Grade A.

7.5.1.2.2 Payload-to-EXPRESS Rack and Fluid Line Bonding

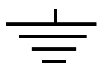
All metallic fluid lines used to connect the payload-to-EXPRESS Rack facility environmental control system (i.e., water, waste gas, GN_2, etc.) will meet a Class S bond. These lines are EXPRESS Rack facility provided. The attachment hardware and methodology to support these fluid lines and routing are specified by the rack integrator.

7.5.2 Circuit Reference Symbols

The circuit reference symbols for use on the EXPRESS Rack payload will be as illustrated and defined as follows:



Structure reference - a connection to EXPRESS rack structure.



Primary power reference - a connection to the EXPRESS Rack primary dc power return.

7.6 POWER CIRCUIT ISOLATION AND GROUNDING

7.6.1 EXPRESS Rack 28 Vdc Primary Power Bus Isolation

Payload input power and return lines shall be isolated from structure by at least 1.0 megohm with a parallel capacitance of ≤10 μF measured at the payload interface connector contacts. Isolation and grounding requirements for the payload power and signal interfaces shall be per Figure 7-10.

7.6.2 Dc Power Ground Reference

EXPRESS Rack dc power supplied to a payload is structure referenced in the EXPRESS Rack and dc isolated from structure ground at the payload by greater than 1 megohm with a parallel capacitance of ≤10 μF. The EXPRESS Rack primary dc power return system is a combination of a hardwired return system and a structure-return system, with the use of the wire return restricted to specific load-sensitive areas.

7.6.3 Payload Secondary Power Isolation and Grounding

EXPRESS Rack 28 Vdc primary power bus and payload secondary power shall be isolated by a minimum of 1 megohm. Secondary power return lines shall be connected to the chassis at no more than one point when termination to chassis is desired. If payload secondary power is distributed to equipment outside the box, the return line is to be grounded to the chassis at the source.

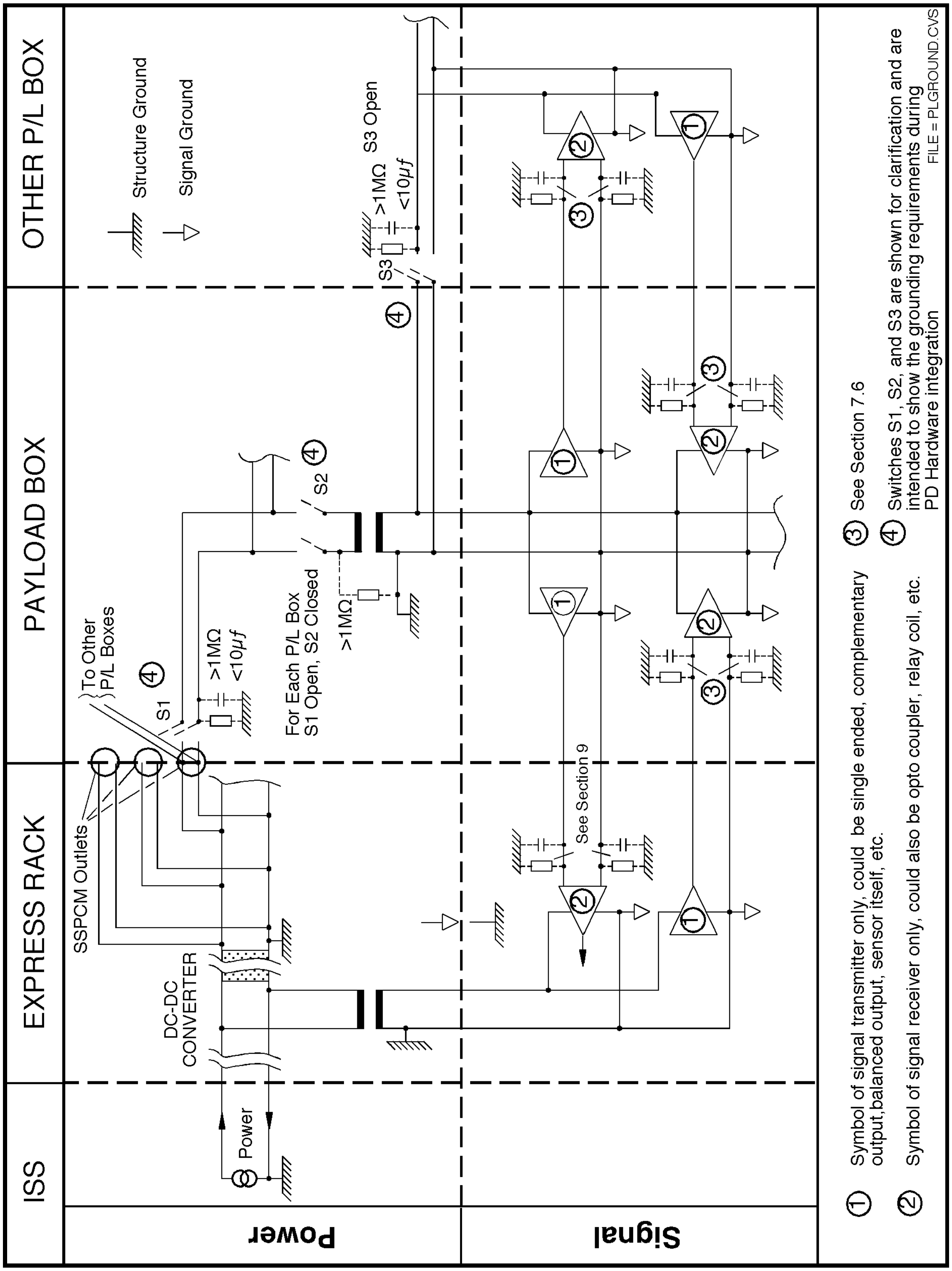


FIGURE 7-10 PAYLOAD ISOLATION

7.6.4 GSE Isolation and Grounding

GSE interfacing with payloads installed in the EXPRESS Rack/Shuttle shall have power returns isolated from payload structures by a minimum of 1 megohm, except where balanced (i.e., differential) circuits are used. In the case of balanced (i.e., differential) circuits, each side of the circuit shall be balanced to ground by no less than 4 kilohm. Coax cables, with their inherent grounding of the signal return to structure, are permitted, provided their interface with other payload or systems does not propagate that ground to circuits that are already referenced to ground at some other point.

7.7 SIGNAL ISOLATION AND GROUNDING REQUIREMENTS

The payload isolation and grounding requirements for received and transmitted signals are as follows:

7.7.1 Ethernet

Isolation and grounding for received and transmitted signals shall be per IEEE 802.3.

7.7.2 RS-422

Isolation and grounding for received and transmitted signals shall be per ANSI/EIA RS-422B.

7.7.3 SSPCM Analog Grounding

Transmitting signal lines shall be referenced to signal ground at the source.

See paragraph 9.3.2, “Analog Driver Characteristics.”

7.7.4 SSPCM Discrete

Received signal and return lines shall be isolated from chassis ground by a minimum of 10 kΩ shunted by equal to or less than 1 nF. Transmitting signal lines shall be referenced to signal ground at the source.

See paragraph 9.4.2, “Discrete Driver and Receiver Characteristics.”

7.7.5 Video

Transmitting signal return lines shall be referenced to signal ground.

See paragraph 9.7, “Video.”

7.7.6 Shield References

The design criteria for wire shield references shall be per the data given in Table 7-I.

SECTION 8, ELECTRICAL WIRING INTERFACE

8.1 GENERAL

Power provisions will be available through rack connector panels at the locations as shown in the PAH, SSP 52000-PAH-ERP, Figures 3-4 and 3-5. Twelve AWG power cables and data cables will be supplied by the EXPRESS Rack facility and installed from the outlet locations to the payload interface. The mating connectors will also be supplied to the payload by the EXPRESS Rack facility. The rack integrator is responsible for routing and specifying the attachment hardware and methodology to support these interfacing cables.

Any EXPRESS Rack payload-provided cables are considered part of the payload and must meet the design requirements of Sections 6 and 7. Any routing of cables by the payload external to the payload envelope will be reviewed and approved by the rack integrator. Cable routing will not impede removal or installation of other payload hardware items.

8.1.1 Connector/Pin Interfaces

Refer to NSTS 21000-IDD-MDK, Section 9.1, for connector and pin interface information in the Shuttle middeck.

8.1.1.1 MDLs/MDL Replacement

Connector pin functions for MDL or MDL replacement payloads shall be as shown in Table 8-I.

8.1.1.1.1 Previously Flown (Shuttle) MDLs/MDL Replacement

Payloads previously flown on the Shuttle that do not use the power interface connector in Table 8-I shall use the mating connector and pin functions called out in

TABLE 8-I POWER INTERFACE CONNECTOR FOR MDL OR MDL REPLACEMENTS

EXPRESS CABLE CONNECTOR: NB6GE14-4SNT MATING CONNECTOR: NB0E14-4PNT

PIN	FUNCTION	AWG	SIGNAL NAME	COMMENT
A	+28 V Power	12	Power	
B	Not Used	12	N/A	
C	28 V Return	12	Power Return	
D	Ground	12	Ground	

Table 8-II to interface with the EXPRESS rack. The payload is responsible for the interface cable and mating connector.

TABLE 8-II ALTERNATE POWER INTERFACE CONNECTOR FOR MDL OR MDL REPLACEMENTS

EXPRESS CONNECTOR: MS27468T17F6SN MATING CONNECTOR: MS27467T17F6PN

PIN	FUNCTION	AWG	SIGNAL NAME	COMMENT
A	+28 V Power	12[1]	Power	
B	+28 V Return	12[1]	Power Return	
C	Ground	12[1]	Ground	
D	Reserved	12	N/A	
E	Reserved	12	N/A	
F	Reserved	12	N/A	

NOTE:

1. Previously flown (Shuttle) payloads, using a power connector with 16 AWG contacts, may use 16 AWG wire in their interface cable with an inline protective device (such as a fuse rated at 15 A or less) to transition from 12 AWG wire to 16 AWG wire (see paragraph 8.1.2).

8.1.1.2 ISIS Drawers

Connector pin functions for ISIS drawer payloads shall be as shown in Table 8-III.

8.1.2 Approved Connectors for EXPRESS Rack Payload Use

It is the intent that all electrical (power (12 AWG)) interface connectors be supplied by the EXPRESS Rack facility. If an EXPRESS Rack payload element chooses to supply electrical connectors and connector contacts that interface with the EXPRESS Rack, they shall be compatible MIL-SPEC connectors per Tables 8-I, 8-II, or 8-III. Connectors that interface between payload equipments should be selected by the PD.

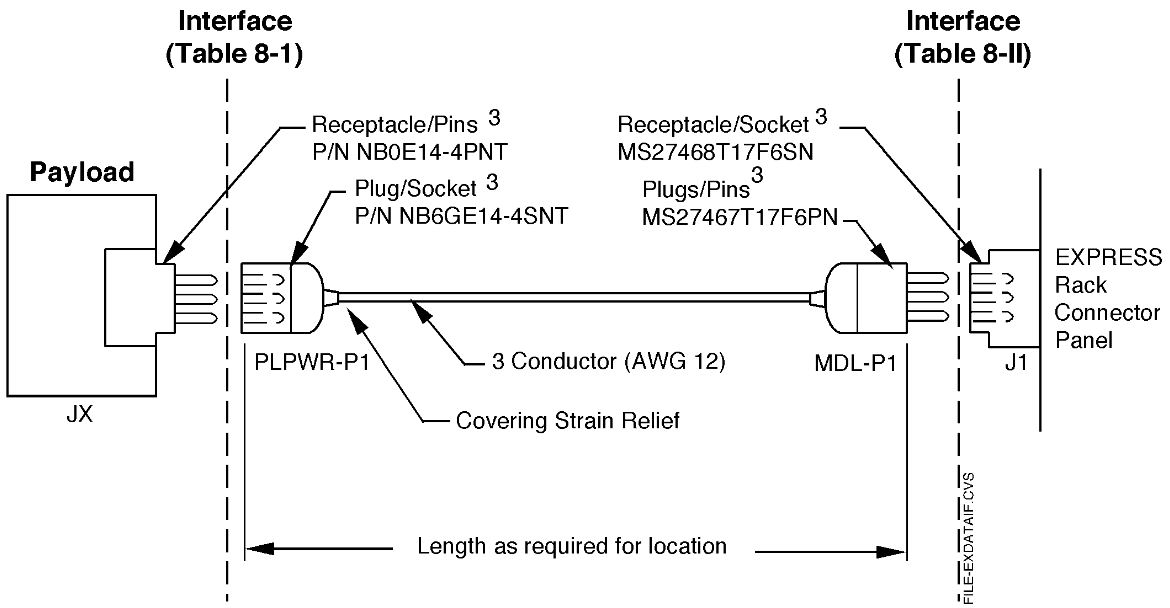
8.2 CABLE SCHEMATICS

Power cables and interface receptacle/plug assignments are shown schematically in Figure 8-1. Data cables and interface receptacle/plug assignments are shown schematically in Figure 8-2.

TABLE 8-III POWER INTERFACE CONNECTOR DEFINITION FOR ISIS DRAWERS

EXPRESS CONNECTOR: M83733/2RA018   MATING CONNECTOR M83733/3RA018

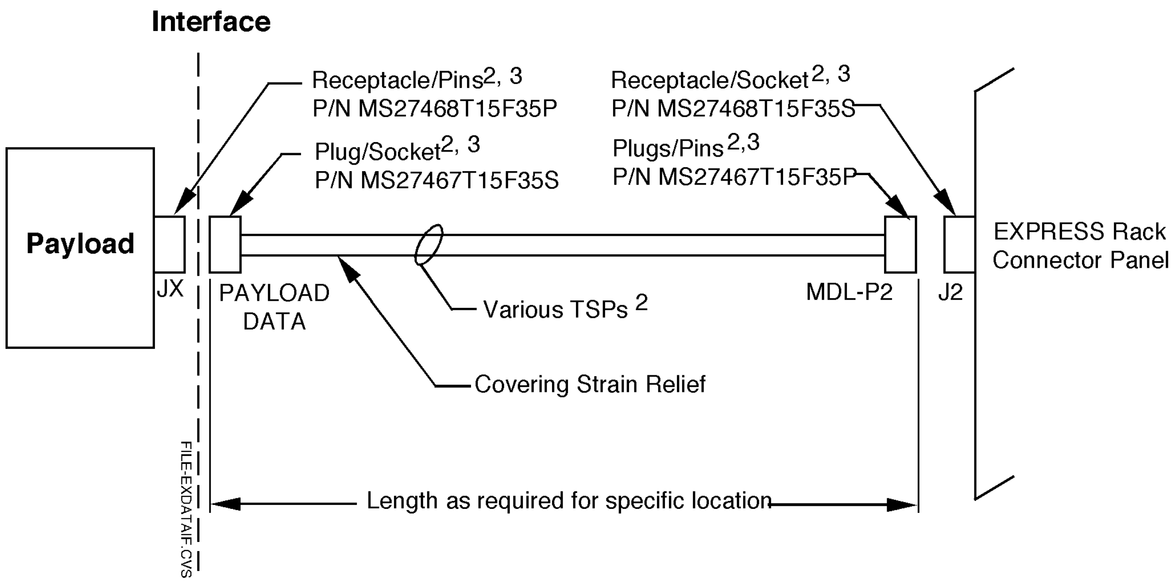
PIN	FUNCTION	AWG	SIGNAL NAME	COMMENT
1	+28 V Power	12	Power	0 - 20 A
2	+28 V Return	12	Power Return	
3	Reserved	12	N/A	
4	Reserved	12	N/A	
5	Reserved	12	N/A	
6	Reserved	12	N/A	
7	Reserved	12	N/A	
8	Reserved	12	N/A	
9	Reserved	12	N/A	
10	Reserved	12	N/A	
11	Reserved	12	N/A	
12	Ground	12	Ground	
13	Reserved	12	N/A	
14	Reserved	12	N/A	
15	Reserved	12	N/A	
16	Reserved	12	N/A	
17	Reserved	12	N/A	
18	Reserved	12	N/A	



NOTES:

1. Previously flown (Shuttle) payloads see (Table 8-II).
2. Cable lengths to be determined by the rack integrator after payloads are manifested in the rack.
3. These items are supplied by the EXPRESS Rack Program.
4. ISIS Drawers do not have the cable interfaces at rear. Interfaces are made via blind mate connectors.
5. The middeck power interfaces (Middeck Utility Power (MUP) and ceiling outlets) are 16 AWG for all connectors except J11 and J21 which are 12 AWG.

FIGURE 8-1 TYPICAL ELECTRICAL POWER CABLE FOR EXPRESS RACK USE ONLY (MDL/MDL REPLACEMENT)



NOTES:

1. Cable lengths to be determined by the rack integrator after payloads are manifested in the rack.
2. These items are supplied by the EXPRESS Rack Program.
3. Refer to Tables 9-I and 9-II for pin/plug assignments.
4. ISIS Drawers do not have the cable interfaces at rear. Interfaces are made via blind mate connectors.

FIGURE 8-2 TYPICAL EXPRESS RACK DATA INTERFACE CABLE(S) FOR EXPRESS RACK USE ONLY (MDL/MDL REPLACEMENT)

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SECTION 9, COMMAND AND DATA HANDLING (C&DH) INTERFACES

There are various C&DH interfaces available for EXPRESS Rack payloads which utilize MDLs, MDL replacement, or ISIS drawers. Figure 9-1 illustrates the payload-to-EXPRESS Rack C&DH interfaces. Each of these interfaces are defined in the following paragraphs. There are no audio interfaces available in the EXPRESS Rack. The EXPRESS laptop and software are defined in Section 11.

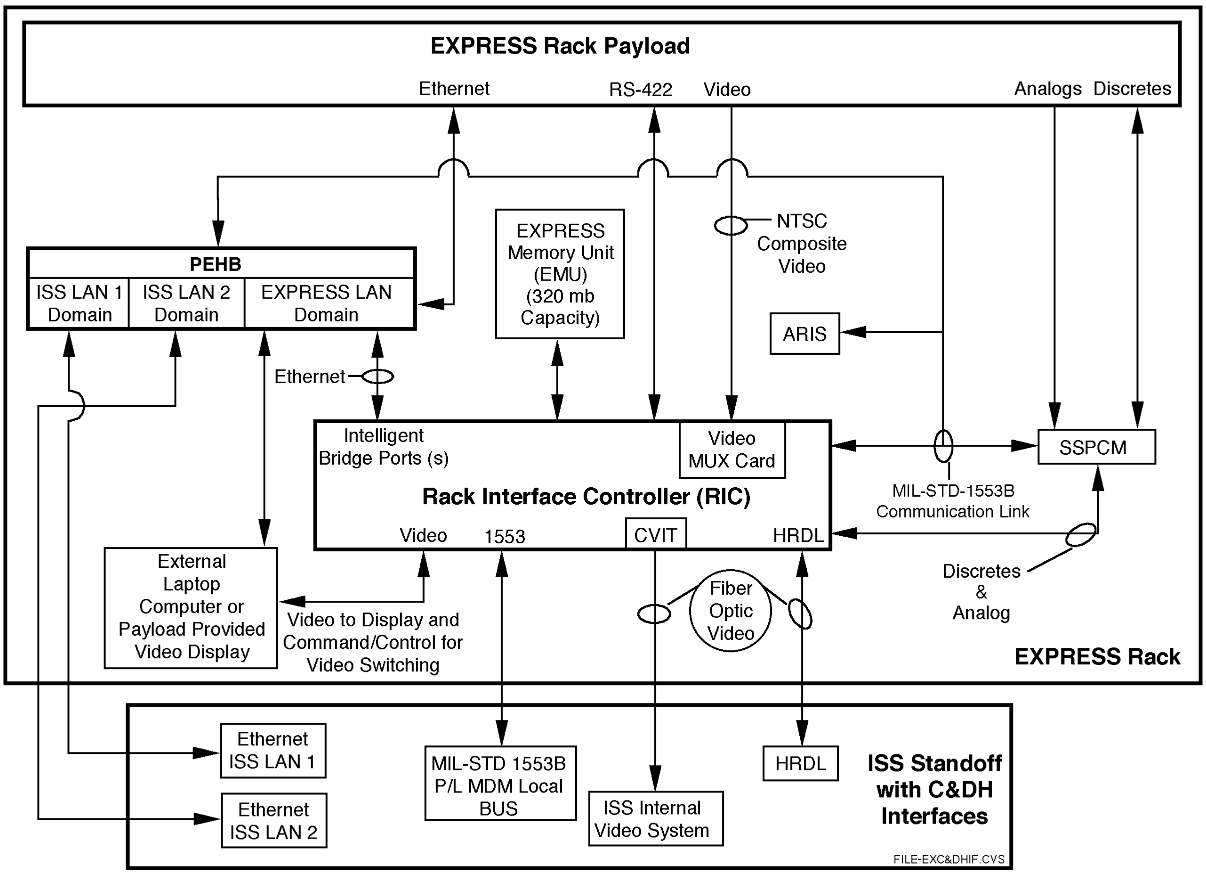

FIGURE 9-1 EXPRESS PAYLOAD C&DH INTERFACES

9.1 RS-422 COMMUNICATIONS

9.1.1 Signal Characteristics

Payloads using an RS-422 serial channel shall meet the interface and signal characteristics requirements of the TIA/EIA 422B specification. The baud rate is payload selectable and will be either 1200, 2400, 4800, 9600, 19200, or 38400 baud. The RS-422 will use eight data bits, one stop bit, and no parity as one character. A message must never have an idle time of more than two contiguous characters between the sync byte and the message checksum word. Messages must be separated by at least a five-character idle time.

9.1.2 Telemetry Format

All payload telemetry to the Rack Interface Controller (RIC) shall be packetized. Telemetry packet format shall be as shown in Table 11-XII.

9.1.3 Request/Command Format

All commands from the RIC to the payload and requests from the payload to the RIC will be packetized. Request/command format shall be as shown in Table 11-XI.

9.1.4 Processing Requirements

The payload shall be capable of receiving, processing, and verifying commands of size as described in the Message Byte Count up to a maximum of 49 l6-bit words per 100 milliseconds.

9.1.5 Connector/Pin Interface

9.1.5.1 MDLs/MDL Replacements

Connector pin functions for MDL or MDL replacement payloads shall be as shown in Table 9-I.

9.1.5.2 ISIS Drawers

Connector pin functions for ISIS drawer payloads shall be as shown in Table 9-II.

TABLE 9-I COMMAND/TELEMETRY CONNECTOR PIN ASSIGNMENTS FOR MIDDECK LOCKER PAYLOADS (Sheet 1 of 2)

Connector P/N: MS27467T15F35S Rack Cable-End Connector		DATA DIRECTION	Connector P/N: MS27468T15F35P Payload Connector	
FUNCTION	PIN		PIN	FUNCTION
RS170 (+)	1	←	1	RS170 (+)
RS170 (-)	2	←	2	RS170 (-)
Spare	3		3	Spare
Analog 1 (+)	4	←	4	Analog 1 (+)
Analog 1 (-)	5	←	5	Analog 1 (-)
Analog 2 (+)	6	←	6	Analog 2 (+)
Analog 2 (-)	7	←	7	Analog 2 (-)
Discrete #1 (+)	8	← or →	8	Discrete #1 (+)
Discrete #1 (-)	9	← or →	9	Discrete #1 (-)
Discrete #2 (+)	10	← or →	10	Discrete #2 (+)
Discrete #2 (-)	11	← or →	11	Discrete #2 (-)
Discrete #3 (+)	12	← or →	12	Discrete #3 (+)
Discrete #3 (-)	13	← or →	13	Discrete #3 (-)
Ethernet RX (+) IN	14	←	14	Ethernet TX (+) OUT
Ethernet RX (-) IN	15	←	15	Ethernet TX (-) OUT
Ethernet TX (+) OUT	16	→	16	Ethernet RX (+) IN
Ethernet TX (-) OUT	17	→	17	Ethernet RX (-) IN
Spare	18		18	Spare
Spare	19		19	Spare
Spare	20		20	Spare
Spare	21		21	Spare
Spare	22		22	Spare
Spare	23		23	Spare
PPCB 01 (+)	24	↔	24	PPCB 01 (+)
PPCB 01 (-)	25	↔	25	PPCB 01 (-)
PPCB 02 (+)	26	↔	26	PPCB 02 (+)
PPCB 02 (-)	27	↔	27	PPCB 02 (-)
Spare	28		28	Spare

TABLE 9-I COMMAND/TELEMETRY CONNECTOR PIN ASSIGNMENTS FOR MIDDECK LOCKER PAYLOADS (Sheet 2 of 2)

Connector P/N: MS27467T15F35S Rack Cable-End Connector		DATA DIRECTION	Connector P/N: MS27468T15F35P Payload Connector	
FUNCTION	PIN		PIN	FUNCTION
PPCB 03 (+)	29	←→	29	PPCB 03 (+)
PPCB 03 (-)	30	←→	30	PPCB 03 (-)
PPCB 04 (+)	31	←→	31	PPCB 04 (+)
PPCB 04 (-)	32	←→	32	PPCB 04 (-)
Spare	33		33	Spare
RS422 RX (+)	34	←	34	RS422 TX (+)
RS422 RX (-)	35	←	35	RS422 TX (-)
RS422 TX (+)	36	→	36	RS422 RX (+)
RS422 TX (-)	37	→	37	RS422 RX (-)

9.2 ETHERNET COMMUNICATIONS

9.2.1 Signal Characteristics

Payloads interfacing with the EXPRESS Rack Payload Ethernet Hub Bridge (PEHB) shall meet the requirements and signal characteristics of IEEE 802.3 (10BASE-T section).

9.2.2 Communications Protocol

Payloads communicating with the RIC (via PEHB), laptop, or other EXPRESS Rack payloads via Ethernet shall use software protocol Transmission Control Protocol/Internet Protocol (TCP/IP). The TCP/IP format is shown in Figure 9-2.

9.2.3 Telemetry Format

All telemetry from the payload to the RIC shall be packetized in accordance with the packet format shown in Table 11-VII.

9.2.4 Request/Command Format

All commands to the payload from the RIC and requests from the payload to the RIC shall be packetized in accordance with the packet format shown in paragraph 11.2.3.5 and Tables 11-VIII through 11-XXI.

TABLE 9-II COMMAND/TELEMETRY CONNECTOR PIN ASSIGNMENTS FOR ISIS DRAWER PAYLOADS (Sheet 1 of 5)

Connector P/N: M83733/2RA131 Rack Connector		DATA DIRECTION	Connector P/N: M83733/3RA131 Payload Connector	
FUNCTION	PIN		PIN	FUNCTION
Reserved	1		1	Reserved
Reserved	2		2	Reserved
Spare	3		3	Spare
Discrete #1 (+)	4	← or →	4	Discrete #1 (+)
Discrete #2 (+)	5	← or →	5	Discrete #2 (+)
Reserved	6		6	Reserved
Reserved	7		7	Reserved
Reserved	8		8	Reserved
Continuity Discrete (+)	9	↔	9	Continuity Discrete (+)
Reserved	10		10	Reserved
Spare	11		11	Spare
Spare	12		12	Spare
Discrete #1 (-)	13	← or →	13	Discrete #1 (-)
Discrete #2 (-)	14	← or →	14	Discrete #2 (-)
Reserved	15		15	Reserved
Reserved	16		16	Reserved
Reserved	17		17	Reserved
Reserved	18		18	Reserved
Reserved	19		19	Reserved
Reserved	20		20	Reserved
Spare	21		21	Spare
Spare	22		22	Spare
Spare	23		23	Spare
Analog #1 (+)	24	←	24	Analog #1 (+)
Reserved	25		25	Reserved
Reserved	26		26	Reserved
Reserved	27		27	Reserved
Reserved	28		28	Reserved
Reserved	29		29	Reserved
Reserved	30		30	Reserved

TABLE 9-II COMMAND/TELEMETRY CONNECTOR PIN ASSIGNMENTS FOR ISIS DRAWER PAYLOADS (Sheet 2 of 5)

Connector P/N: M83733/2RA131 Rack Connector		DATA DIRECTION	Connector P/N: M83733/3RA131 Payload Connector	
FUNCTION	PIN		PIN	FUCTION
Reserved	31		31	Reserved
Spare	32		32	Spare
Spare	33		33	Spare
Reserved	34		34	Reserved
Reserved	35		35	Reserved
Reserved	36		36	Reserved
Reserved	37		37	Reserved
Reserved	38		38	Reserved
Reserved	39		39	Reserved
Reserved	40		40	Reserved
Reserved	41		41	Reserved
Spare	42		42	Spare
Spare	43		43	Spare
Analog #1 (-)	44	←	44	Analog #1 (-)
Reserved	45		45	Reserved
Reserved	46		46	Reserved
RS170 (+)	47	←	47	RS170 (+)
Reserved	48		48	Reserved
Reserved	49		49	Reserved
Reserved	50		50	Reserved
PPCB 01 (+)	51	↔	51	PPCB 01 (+)
Reserved	52		52	Reserved
Spare	53		53	Spare
Spare	54		54	Spare
Not used	55	←	55	Not used
Reserved	56		56	Reserved
Spare	57		57	Spare
Reserved	58		58	Reserved
Reserved	59		59	Reserved
Reserved	60		60	Reserved
PPCB 01 (-)	61	↔	61	PPCB 01 (-)

TABLE 9-II COMMAND/TELEMETRY CONNECTOR PIN ASSIGNMENTS FOR ISIS DRAWER PAYLOADS (Sheet 3 of 5)

Connector P/N: M83733/2RA131 Rack Connector		DATA DIRECTION	Connector P/N: M83733/3RA131 Payload Connector	
FUNCTION	PIN		PIN	FUNCTION
PPCB 02 (-)	62	↔	62	PPCB 02 (-)
Spare	63		63	Spare
Spare	64		64	Spare
Spare	65	←	65	Spare
Reserved	66		66	Reserved
RS 422 TX (+)	67	→	67	RS 422 RX (+)
RS170 (-)	68	←	68	RS170 (-)
Reserved	69		69	Reserved
Reserved	70		70	Reserved
Spare	71		71	Spare
Reserved	72		72	Reserved
Spare	73		73	Spare
Spare	74		74	Spare
Spare	75		75	Spare
Reserved	76		76	Reserved
Spare	77		77	Spare
RS 422 RX (+)	78	←	78	RS 422 TX (+)
Reserved	79		79	Reserved
Reserved	80		80	Reserved
Reserved	81		81	Reserved
Reserved	82		82	Reserved
PPCB 02 (+)	83	↔	83	PPCB 02 (+)
Spare	84		84	Spare
Spare	85		85	Spare
Spare	86		86	Spare
Reserved	87		87	Reserved
RS 422 TX (-)	88	→	88	RS 422 RX (-)
Spare	89		89	Spare
Reserved	90		90	Reserved
Reserved	91		91	Reserved
Spare	92		92	Spare

TABLE 9-II COMMAND/TELEMETRY CONNECTOR PIN ASSIGNMENTS FOR ISIS DRAWER PAYLOADS (Sheet 4 of 5)

Connector P/N: M83733/2RA131 Rack Connector		DATA DIRECTION	Connector P/N: M83733/3RA131 Payload Connector	
DIRECTION	PIN		PIN	FUNCTION
PPCB 03 (+)	93	↔	93	PPCB 03 (+)
Reserved	94		94	Reserved
Reserved	95		95	Reserved
Spare	96		96	Spare
Reserved	97		97	Reserved
Spare	98		98	Spare
RS 422 RX (-)	99	←	99	RS 422 TX (-)
Reserved	100		100	Reserved
Reserved	101		101	Reserved
Spare	102		102	Spare
PPCB 03 (-)	103	↔	103	PPCB 03 (-)
Reserved	104		104	Reserved
Ethernet RX (+)	105	←	105	Ethernet TX (+)
Reserved	106		106	Reserved
Reserved	107		107	Reserved
Reserved	108		108	Reserved
Reserved	109		109	Reserved
Reserved	110		110	Reserved
Spare	111		111	Spare
Spare	112		112	Spare
PPCB 04 (+)	113	↔	113	PPCB 04 (+)
Spare	114		114	Spare
Reserved	115		115	Reserved
Ethernet RX (-)	116	←	116	Ethernet TX (-)
Reserved	117		117	Reserved
Spare	118		118	Spare
Reserved	119		119	Reserved
Reserved	120		120	Reserved
Continuity Discrete (-)	121	↔	121	Continuity Discrete (-)
Spare	122		122	Spare
Spare	123		123	Spare

TABLE 9-II COMMAND/TELEMETRY CONNECTOR PIN ASSIGNMENTS FOR ISIS DRAWER PAYLOADS (Sheet 5 of 5)

Connector P/N: M83733/2RA131 Rack Connector		DATA DIRECTION	Connector P/N: M83733/3RA131 Payload Connector	
FUNCTION	PIN		PIN	FUNCTION
PPCB 04 (-)	124	←→	124	PPCB 04 (-)
Reserved	125		125	Reserved
Spare	126		126	Spare
Reserved	127		127	Reserved
Ethernet TX (+)	128	→	128	Ethernet RX (+)
Ethernet TX (-)	129	→	129	Ethernet RX (-)
Reserved	130		130	Reserved
Reserved	131		131	Reserved

9.2.5 Processing Requirements

The payload shall be capable of receiving, processing, and verifying the command size as described on Message Byte Count up to 49 16-bit words per 100 milliseconds.

9.2.6 Connector/Pin Interface

9.2.6.1 MDLs/MDL Replacements

Connector pin functions for MDL or MDL replacement payloads shall be as shown in Table 9-I.

9.2.6.2 ISIS Drawers

Connector pin functions for ISIS drawer payloads shall be as shown in Table 9-II.

9.2.7 Communications to Laptop

Ethernet communication with the EXPRESS Rack laptop computer is via the EXPRESS Rack PEHB.

	MSB … LSB							
IP	Version	IHL	Type of Service	Total Length				
	Identification			Flags (3)	Fragment Offset (13)			
	Time to Live	Protocol	Header Checksum					
	Source Address							
	Destination Address							
TCP	Source Port			Destination Port				
	Sequence Number							
	Acknowledgement Number							
	Data Offset (4)	Reserved (6)	URG	ACK	PSH	RST	SYN	FIN
	Window							
	Checksum			Urgent Pointer				
DATA	Your data . . .							

FIGURE 9-2 TCP/IP FORMAT DEFINITION FOR ETHERNET COMMUNICATIONS

9.3 ANALOG COMMUNICATIONS

It should be noted that all analog communications are via the SSPCM. The sampling rate of the payload data by the RIC from the SSPCM will be 1.0 Hz, 10 Hz, or 100 Hz. The SSPCM samples at 1 kHz. All analogs for a single payload location must be sampled at the same rate. The resolution/accuracy of the payload data by the SSPCM will be 12 bits analog-to-digital conversion with a ±1 percent of full scale accuracy.

9.3.1 Signal Characteristics

An analog signal input to the EXPRESS Rack shall be a -5 Vdc to +5 Vdc output signal (i.e., differential input to the SSPCM).

9.3.2 Analog Driver Characteristics

The electrical characteristics of the payload analog driver circuit (output from the payload) shall be compatible with the SSPCM receiver circuit illustrated in Figure 9-3.

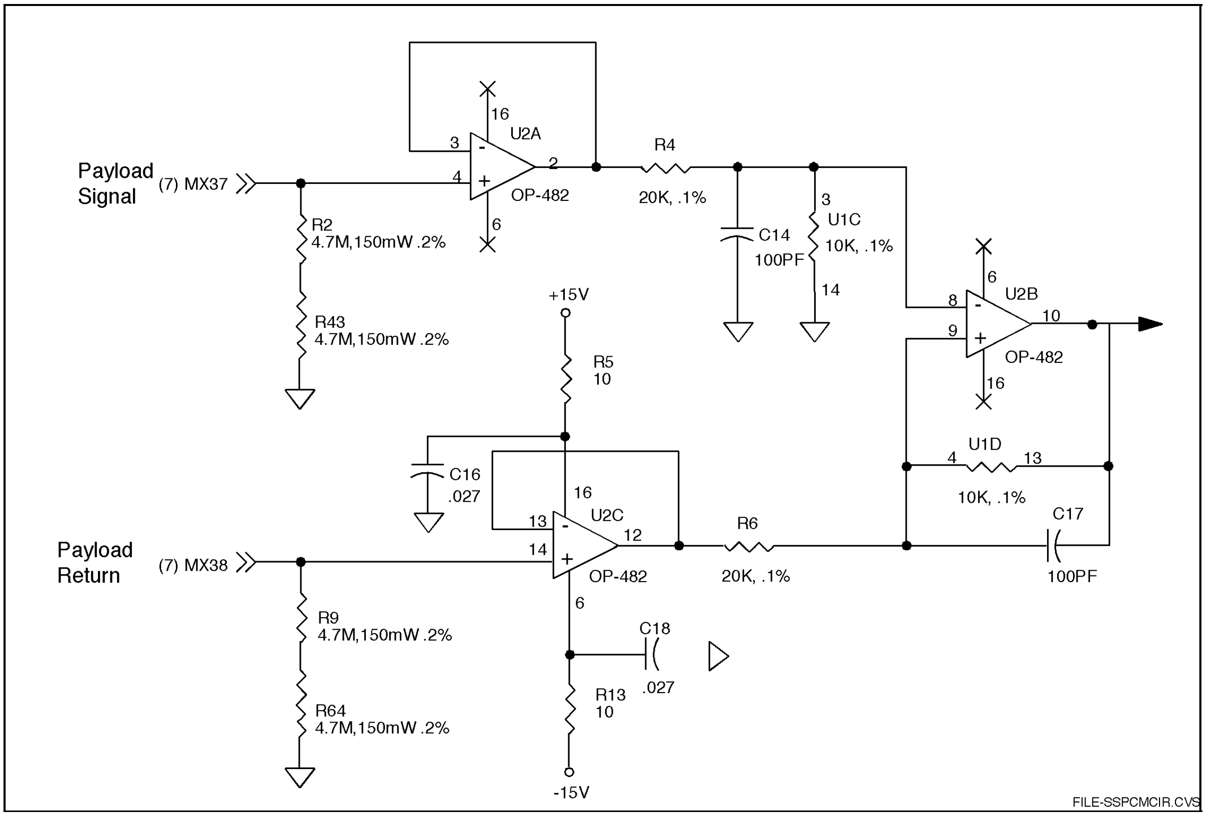

FIGURE 9-3 INPUT AMPLIFIER FOR ANALOG SIGNALS TO BE DIGITIZED (SSPCM ANALOG RECEIVER CIRCUIT)

9.3.3 Connector/Pin Interface

9.3.3.1 MDLs/MDL Replacement

Connector pin functions for MDL or MDL replacement payloads shall be as shown in Table 9-I.

9.3.3.2 ISIS Drawers

Connector pin functions for ISIS drawer payloads shall be as shown in Table 9-II.

9.4 DISCRETE COMMUNICATIONS

All discrete communications are via the SSPCM. The following paragraphs are written with the SSPCM as the reference (i.e., outputs are from the SSPCM, and inputs are to the SSPCM). Discretes are bi-directional and programmed at the SSPCM. The sampling rate of the payload data by the RIC from the SSPCM will be 1 or 10 Hz. The SSPCM samples at 1 kHz. All discretes for a single payload position (MDL or ISIS drawer) must be sampled at the same rate.

9.4.1 Discrete Signal Characteristics

The discrete output (from the SSPCM) signal is a differential signal, and the discrete input (to the SSPCM) is a differential signal.

9.4.1.1 Discrete Output Low Level

The PD hardware shall be compatible with a digital “zero” level output of -3.5 Vdc line-to-line.

9.4.1.2 Discrete Output High Level

The PD hardware shall be compatible with a digital “one” level output of +3.5 Vdc line-to-line.

9.4.1.3 Discrete Output Maximum Fault Current

The PD hardware shall be compatible with and not be damaged by indefinite exposure to a misconnection to -27 to 32 Vdc source or sustained short. Output current under these conditions will be limited to 27 mA continuous and up to 150 mA for a duration of up to 1 sec.

9.4.1.4 Discrete Input Low Level

The PD hardware shall be compatible with a low level input (logic low level) when the input is -0.5 Vdc to +2.0 Vdc.

9.4.1.5 Discrete Input High Level

The PD hardware shall be compatible with a high level input (logic high level) when the input is +2.5 Vdc to +6.0 Vdc.

9.4.1.6 Discrete Input Maximum Fault Voltage

The PD hardware shall not output any voltage outside the range of -27 to +32 Vdc indefinitely due to any fault condition.

9.4.2 Discrete Driver and Receiver Characteristics

The electrical characteristics of the payload discrete driver circuit shall be compatible with the SSPCM receiver circuit illustrated in Figure 9-4. The electrical characteristics of the payload discrete receiver circuit shall be compatible with the SSPCM driver circuit illustrated in Figure 9-4.

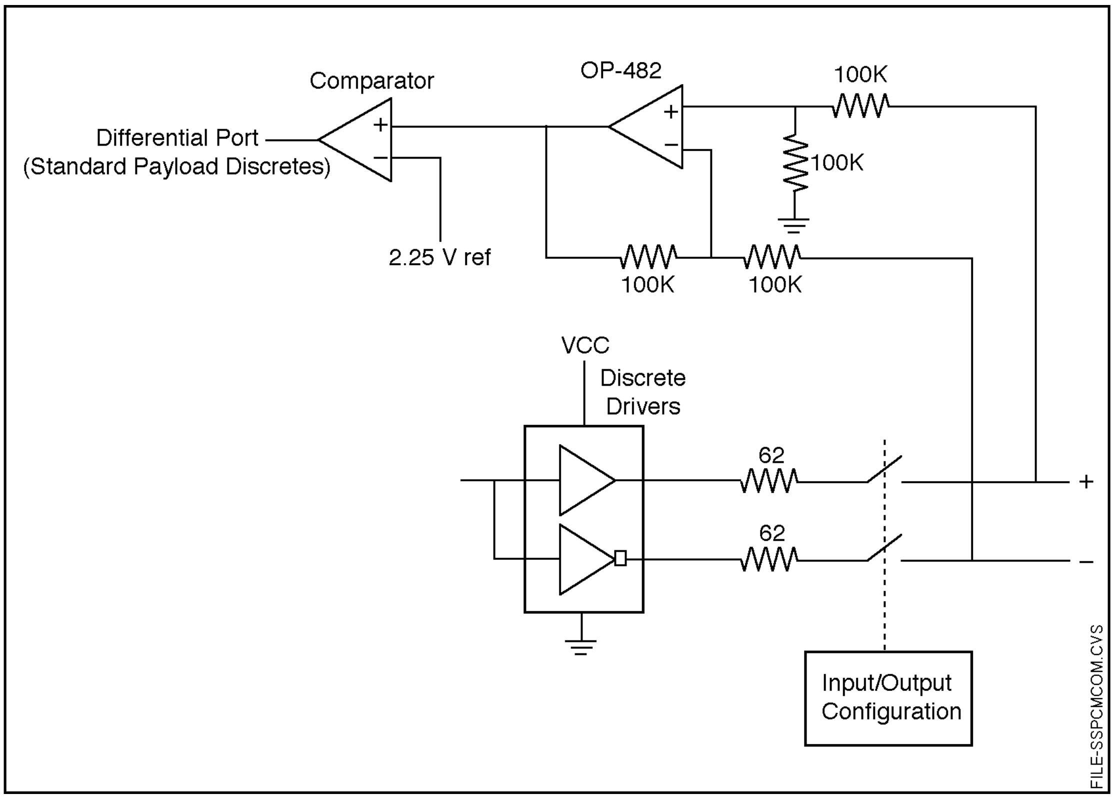

FIGURE 9-4 SSPCM DISCRETE RECEIVER CIRCUIT AND DRIVER CIRCUIT FOR DISCRETE COMMUNICATIONS

9.4.3 Connector/Pin Interface

9.4.3.1 MDLs/MDL Replacement

Connector pin functions for MDL or MDL replacement payloads shall be as shown in Table 9-I.

9.4.3.2 ISIS Drawers

Connector pin functions for ISIS drawer payloads shall be as shown in Table 9-II.

9.5 CONTINUITY DISCRETE JUMPER

ISIS drawer payloads shall jumper the Command/Telemetry connector (P2) pin contact 9 to pin contact 121 per Table 9-II. This is to allow software to verify that the connector is mated when the ISIS drawer is in the installed position.

9.6 POINT-TO-POINT COMMUNICATIONS BUS (PPCB)

The PPCB provides hardwired communication between adjacent payloads (ISIS drawers or MDLs) within the same EXPRESS Rack. PPCB hardwired connectivity is as follows: M1 to M2 and M5, M2 to M1 and M3, M3 to M2 and M4, M4 to M3 and S1, S1 to M4 and S2, S2 to S1 and M8, M8 to S2 and M7, M7 to M6 and M8, M6 to M5 and M7, and M5 to M1 and M6. The pin functions required for the PPCB shall be as defined in Tables 9-I and 9-II.

9.7 VIDEO

Payload shall provide an analog balanced differential video output signal which is derived from the single-ended video signal specified by ANSI/SMPTE 170M. When differentially terminated in 75 ohms, the differential signal shall have the same color encoding, timing, and relative signal levels as defined by ANSI/SMPTE 170M. The balanced differential signal shall be derived from the single-ended signal as specified in the following:

9.7.1 Payload Video Characteristics

9.7.1.1 Input Impedance

The balanced differential output shall be designed with a 75-ohm source impedance. Each differential video input to the EXPRESS Rack shall be differentially terminated in 75 ± 5 ohms with the EXPRESS Rack.

9.7.1.2 Sync Tip

The positive pin of the balanced differential output shall provide a nominal 0.5 volt peak to peak signal with sync tip (-40 IRE in SMPTE 170M) at 0 V and peak white (100 IRE in SMPTE 170M) at 0.5 V (Note: As specified in ANSI/SMPTE 170M for color video signals, the encoded subcarrier may exceed peak white levels).

9.7.1.3 Blanking Level

The negative pin of the balanced differential output shall provide a nominal 0.5 V peak to peak signal, in phase quadrature (inverted) to the positive output, with sync tip (-40 IRE in SMPTE 170M) at 0 V and peak white (100 IRE in SMPTE 170M) at negative 0.5 V (Note: As specified in ANSI/SMPTE 170M for color video signals, the encoded subcarrier may exceed peak white levels).

9.7.1.4 White Reference

The balanced differential output shall have no more than a ± 0.1 Vdc common mode component measured with respect to the input ground reference pin.

9.7.2 Deviations to Video Standard

SMPTE 170M specifies very tight tolerances on video timing and signal levels. The actual video performance requirements for a payload source will be determined by the intended use by that individual payload. Where individual payload video performance requirements are less stringent, the following deviations are permitted to relax required video tolerances:

A. The video source may provide a monochrome video signal, which contains no color burst.

B. The video source may provide a color video signal in which the phase of color burst is not defined with respect to the leading edge of horizontal sync.

C. The video source may provide a color video signal in which the frequency of color subcarrier deviates from nominal as specified in ANSI/SMPTE 170M by up to ± 100 parts per million, provided that the rate of change of subcarrier frequency does not exceed 0.1 Hz per second.

D. The video source may provide a video signal in which the timing of horizontal and vertical synchronization pulses deviates from nominal as specified in ANSI/SMPTE 170M by up to ± 100 parts per million, provided that the rate of change of horizontal or vertical timing does not exceed 0.3 parts per million per second.

E. The video source may relax the tolerance specified in ANSI/SMPTE 170M on the relative amplitudes of sync tip and peak white to -40 ± 4 IRE and 100 ± 10 IRE respectively.

9.7.3 Connector/Pin Interface

Connector and pin functions for the MDL or MDL replacement payloads are shown in Table 9-I, and connector and pin functions for ISIS drawer payloads are shown in Table 9-II. These pin interfaces shall be used.

SECTION 10, ENVIRONMENTAL INTERFACES

This section defines the environments for which the EXPRESS Rack payload shall be compatible. This section contains only those environmental requirements which are not covered in the specific discipline sections (i.e., Electrical, Thermal, EMC/EMI, Structures, etc.). The environments defined in the following paragraphs should be considered design-to requirements and should provide a basis for any applicable analyses, tests, or inspections which must be conducted during the payload development process.

10.1 PAYLOAD EQUIPMENT SURFACE CLEANLINESS

A. Design shall allow external surfaces to be cleaned with solvents and equipment available at the launch site (lint free cloths/swabs, isopropyl alcohol, demineralized water etc.). Visibly clean “SENSITIVE” is the baseline level for all payloads.

B. Payloads shall be delivered clean (external and accessible surfaces) and protected to visibly clean “SENSITIVE” or better as negotiated and as prescribed in JSC SN-C-0005. Cleaning fluids will be per NSTS 08242.

10.2 ILLUMINATION REQUIREMENTS - LIGHTING DESIGN

The general illumination of the Space Station in the aisle will be a minimum of 108 lux (10 foot-candles) of white light. This illumination will be sufficient for ordinary payload operations performed in the aisle. Specific levels are shown in Table 10-I.

Payloads must meet all of the following requirements:

10.2.1 Work Surface Specularity

Payload work surface specularity shall not exceed 20 percent. Colors listed in Table 12-II meet this requirement.

10.2.2 Supplemental Lighting

Payloads shall provide supplemental lighting at worksites to meet the illumination levels in Table 10-II.

10.2.3 Direct Light Sources

Light sources shall be dimmable.

TABLE 10-I ISS LABORATORY ILLUMINATIONS LEVELS

AREA OR TASK	AVAILABLE LEVELS	
	LUX	(FOOT-CANDLES)
General	108	(10)
Stowage Areas	108	(10)
Health Maintenance	215	(20)
First Aid	269	(25)
Surgical	1076	(100)
I.V. Treatment	807	(75)
Exercise	538	(50)
Hyperbaric Clinical Lab	538	(50)
Imaging Televideo	538	(50)
Night Lighting	21	(2)
Emergency Lighting	32	(3)

NOTE: Levels are measured at the task site or 30 in (760 mm) above floor. All levels are minimums.

TABLE 10-II PAYLOAD REQUIRED ILLUMINATION LEVELS

TYPE OF TASK	REQUIRED LUX (FOOT-CANDLES)*
Medium payload operations (not performed in the aisle) (e.g., Payload changeout and maintenance)	325 (30)
Fine payload operations (e.g., instrument repair)	1075 (100)
Medium glovebox operations (e.g., general operations, experiment setup)	975 (90)
Fine glovebox operations (e.g., detailed operations, protein crystal growth, surgery/dissection)	1450 (135)

*As measured at the task site.

10.2.4 Glovebox Lighting

Lighting in gloveboxes, excluding spot illumination, shall not exceed a brightness ratio of 3:1.

10.2.5 Portable Utility Lighting

Medium payload operational tasks shall utilize the ISS portable utility light specified in JSC 27199.

10.3 LASER REQUIREMENTS

10.3.1 Laser Design and Operation in Compliance with ANSI Standard Z136.1-1993

Payload systems employing lasers shall be designed and operated in accordance with the ANSI Standard Z136.1-1993 except where the unique environment or mission requirements clearly make it unreasonable to do so. The hazard analysis for a system must specifically address each instance where it does not meet ANSI Standard Z136.1-1993 requirements.

10.3.2 Non-Ionizing Radiation

Payload non-ionizing emissions shall not exceed the exposure limits for personnel radiation as specified in SSP 50005, 5.7.3.2.1 for RF, laser, and ultraviolet exposure.

Note: Above values are under review.

10.3.3 Safe Operation

Procedures for the safe operation of laser and optical radiation sources shall be provided by the PD.

10.3.4 Accidental Exposures

Payload procedures and equipment shall be provided to enable positive protective measures to be taken to prevent accidental exposures from laser and optical radiation.

10.3.5 Laser and Optical Radiation Monitoring

Based on the identified sources of laser and optical radiation, monitoring and warning systems shall be provided by the PD consistent with the potential hazard from each source.

10.3.6 Personnel Protection Devices

Based on the safety requirements and results for the electromagnetic hazards analysis, personnel protective device requirements (eyewear, clothing) shall be established and the requisite personnel equipment shall be provided by the PD.

10.4 RADIATION REQUIREMENTS

Payloads are required to meet the radiation emission requirements specified in Section 7 of this IDD. Payloads on board the ISS are exposed to natural and induced radiation environments. The SSP 52000-PAH-ERP provides design guidelines and reference material addressing this subject including a radiation dose requirement of 30 rad (Si) per year.

10.4.1 Payload Contained or Generated Ionizing Radiation

Payloads containing or using radioactive materials or materials that generate ionizing radiation must be identified and approval obtained for their use by the ISS.

Radioactive materials shall comply with appropriate license requirements at the planned launch and landing sites as well as the ISS program.

Design Guidance: Descriptive data is to be provided in accordance with NSTS 13830 (each radiation source is to be documented using a completed JSC Form-44, "Ionizing Radiation Source Data Sheet Space Flight Hardware and Applications"). Major radioactive sources require approval by the Interagency Nuclear Safety Review Panel through the NASA coordinator for the panel (NSTS 1700.7, Addendum 212.1).

10.4.2 Single Event Effect (SEE) Ionizing Radiation

Materials and equipment shall not produce an unsafe condition or one that could cause damage to the ISS, EXPRESS Rack, or other payloads as a result of exposure to SEE ionizing radiation assuming exposure levels specified in SSP 30512, paragraph 3.2.1, with a shielding thickness of 25.4 mm (1000 mils).

Design Guidance: SEE is a generalized category of anomalies that result from a single ionizing particle. This term includes such effects as single event upsets, transients, latchup, permanent upset, and device burnout effects.

10.4.3 Radiation Dose Requirements

Payloads should expect a total dose (including trapped protons and electrons) of 30 Rads (Si) per year of ionizing radiation. A review of the dose estimates in the ISS (SAIC-TN-9550) may show ionizing radiation exposure to be different than 30 Rads (Si) per year, if the intended location of the payload in the ISS is known.

10.5 ATMOSPHERE REQUIREMENTS

See Table 5-I.

10.5.1 Oxygen Consumption

The EXPRESS Rack payload consumption of atmospheric oxygen shall not exceed 0.10 kg per day (0.24 lbm per day).

10.5.2 Chemical Releases

Chemical releases to the cabin air shall be in accordance with paragraphs 209.1a and 209.1b in NSTS 1700.7 Addendum.

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SECTION 11, LAPTOP COMPUTERS AND SOFTWARE

The EXPRESS Rack provides C&DH interfaces for payload use. The RIC, SSPCM, and PEHB provide direct interfaces to the EXPRESS payloads. Bidirectional communication with equipment on board ISS and to ground facilities are through these equipment items. File transfer downlink of payload data files via PL MDM is prohibited due to operations constraints.

The RIC provides digital and analog data management services, including, but not limited to, data formatting, data multiplexing, and command distribution and serves as an interface buffer between EXPRESS and the ISS C&DH. The RIC interfaces to the ISS via the MIL-STD-1553 bus as Low Rate Data Link (LRDL), Ethernet via the PEHB as Medium Rate Data Link (MRDL), fiber optical as High Rate Data Link (HRDL), and Pulse Frequency Modulated (PFM) video. The low rate link to the Payload Multiplexer/Demultiplexer (PL MDM) is for commands, uplink files, Ancillary Data (payload unique and Broadcast), Payload Executive Processor (PEP) service requests and responses, time, Health and Status data, and low rate telemetry data. The MRDL to the Payload Ethernet Hub Gateway (PEHG) is for payload-to-payload communication and medium rate telemetry downlink. The HRDL is for high rate telemetry downlink. All messages (other then video) between the RIC and ISS are in Consultative Committee for Space Data Systems (CCSDS) format. Messages between the RIC and payload or laptop are in EXPRESS packet format with sync word (55AA) and EXPRESS Header. When the RIC forwards each message to the desired destination, the EXPRESS Header will be kept, except the RIC will remove the EXPRESS Header from the Health and Status data before sending it to the PL MDM.

The SSPCM provides power to the EXPRESS Rack payloads and subsystem and provides an interface for analog/discrete data collection and an interface for discrete output commands. The SSPCM and the RIC communicate via MIL-STD-1553B interfaces and various discrete signals.

The Ethernet Local Area Network (LAN) located within the EXPRESS Rack allows payloads to communicate to the EXPRESS laptop, to other payloads in the same EXPRESS Rack, or to other equipment/payloads outside the rack via the PEHB.

The PEP is the part of the PL MDM that serves as a single point of control for payload data and commands in the ISS C&DH system. From the prospective of EXPRESS payloads the PEP and the PL MDM are the same.

The RIC inserts the primary and the secondary CCSDS headers for downlink telemetry packets and messages to the PL MDM. The RIC builds the CCSDS header per the assigned Application Process Identifier (APID) in the RIC table. The payload will not see the CCSDS header except for broadcast ancillary data where the CCSDS header is included as part of the packet that is sent to the payload from the RIC. For uplink commands, the

Huntsville Operations Support Center (HOSC) will generate the CCSDS header. The only important portion in CCSDS header is the APID.

11.1 LAPTOP COMPUTERS

There are three laptop computers available for the payload to use. They are described in the following paragraphs. Payloads are not allowed to utilize/manifest their own laptop. The software which interfaces to the payload is also identified in the subsequent paragraphs.

The PGSC is used in the Shuttle (middeck or flight deck). The PCS is the primary laptop interface with the ISS subsystems. The PCS does not physically interface with the EXPRESS Rack or payload nominally. The EXPRESS Rack Laptop (LAP) is the primary payload interface with the EXPRESS Rack RIC and the payloads within an EXPRESS Rack.

11.1.1 Payload and General Support Computer

PGSC utilization, operations, and constraints are defined in NSTS 21000-IDD-760XD. Payloads using the PGSC shall comply with the applicable requirements in NSTS 21000-IDD-760XD and the requirements in Section 11.1.1.

11.1.1.1 PGSC Electrical Power Characteristics

11.1.1.1.1 Payload-Powered PGSC

The PGSC may be powered through the payload which is specified in paragraph 5.4 of NSTS 21000-IDD-760XD. Note: The power table in the payload-unique EIA must include PGSC requirements.

11.1.1.1.2 Orbiter-Powered PGSC

The PGSC may obtain electrical power through available Shuttle middeck outlets as specified in paragraph 9.1 of NSTS 21000-IDD-MDK. Electrical power requirements and interface characteristics for the PGSC are specified in paragraph 5.1 of NSTS 21000-IDD-760XD.

11.1.1.2 PGSC Communication/Power Interfaces Cables

11.1.1.2.1 RS-232 Communication Cables (Orbiter PGSC)

The RS-232 cables, connectors, and pin functions for payload usage shall be as defined in paragraph 7.2.1 of NSTS 21000-IDD-760XD. The RS-232C cables are provided for experiments located in the orbiter cabin.

11.1.1.2.2 RS-422 Communication Cables (Orbiter PGSC)

The RS-422 cables, connectors, and pin functions for payload usage shall be as defined in paragraph 7.2.2 of NSTS 21000-IDD-760XD. The RS-422 cable provides a communication link between the PGSC and payload in the payload bay.

11.1.1.2.3 Power Cables (Orbiter PGSC)

Dc power cables, connectors, and pin functions shall be per paragraph 7.1 of NSTS 21000-IDD-760XD.

11.1.1.3 Software (Orbiter PGSC)

All unique payload software and applications used on the PGSC will be payload provided. The payload may use standard 3.5 in floppy diskettes, replaceable hard drives, or Personal Computer Memory Card International Association (PCMCIA) cards, but this is dependent on the exact PGSC model available in inventory at the time of request. The PD shall show compatibility of these user accessories with the PGSC model to be used. It is recommended that the payload make arrangement to allow for testing the experiment hardware with the intended software installed in the PGSC.

11.1.2 EXPRESS Rack Laptop

The EXPRESS Rack laptop is used to display EXPRESS Rack facility subsystem status and communicate with payload hardware elements within the EXPRESS Rack and display video. The EXPRESS Rack laptop computer is the IBM Thinkpad 760 XD. The configuration includes 64 MB of RAM, a 3.0-GB hard drive, and the Windows NT 4.0 operating system. Other specific hardware characteristics are listed below:

A. 166-MHz Pentium Processor

B. 3.0-GByte removable hard drive

C. 8X CD ROM

D. 1.44-MByte floppy disk drive

E. 64-MByte EDO RAM

F. 13.3 in Active Matrix XGA display

G. PCMCIA slot with Ethernet Card

H. RS-232, parallel, joystick, external floppy, and external data ports

I. Expansion chassis bus (AT/PCI)

The EXPRESS Rack laptop application software is used for control of the rack equipment, display of video, and display of rack status. The rack application is developed using Microsoft Visual Basic (professional edition 5.0) and Visual C++ (version 5.0) for the GUI. Figure 11-1 illustrates at a high level the end-to-end description of command flows from the EXPRESS Rack laptop using PD applications resident in the laptop to a payload. There are no direct physical interfaces between this laptop and the payload; however, the computer can be used to monitor the payload, send requests, display video, etc., which are subject to operational and hardware-sharing constraints.

The EXPRESS Rack laptop obtains 20 to 16 Vdc operating power from the laptop power converter through a power outlet on the EXPRESS Rack front panel. This interfacing power cable will not be connected directly to other payload equipment.

EXPRESS Rack laptop data/power/video interface cables are connected between the laptop and rack Lower Connector Panel (LCP) for nominal operations and are EXPRESS provided.

Note: Physical contact with the EXPRESS Rack laptop attached to an ARIS rack is prohibited. Commanding to the payload must be done remotely.

11.1.3 ISS Portable Computer System

Reference SSP 52052-IDD-PCS for design requirements and information regarding the ISS PCS. Payloads planning to use the ISS PCS shall comply with the applicable requirements in SSP 52052-IDD-PCS and associated schedule templates. Payloads must plan to utilize the EXPRESS Rack laptop before attempting to use the PCS. The ISS PCS does not have an Ethernet interface. The operating system is Solaris.

11.2 EXPRESS RACK SOFTWARE

Figure 11-2 depicts the EXPRESS Rack RIC Computer Software Configuration Item (CSCI) interfaces to the payloads and other items within the EXPRESS Rack. Table 11-I summarizes the EXPRESS Rack RIC CSCI direct interfaces to the payload item. There are other services available to payloads shown in Figure 11-2; however, the CSCI interfaces between the Ethernet payload and the ISS MRDL must go through the PEHB (i.e., indirect interface). In this section, messages sent to the payload will be referred to as “commands,” and messages sent from the payload will be referred to as “requests.”

Science and/or Health and Status information sent from the payload will be referred to as either “data” or “telemetry.” Figure 11-3 illustrates at a high level the end-to-end description of command flow for a command from the PEP (such as a ground and timeline command) to a payload. Figure 11-4 illustrates at a high level the end-to-end description of the request

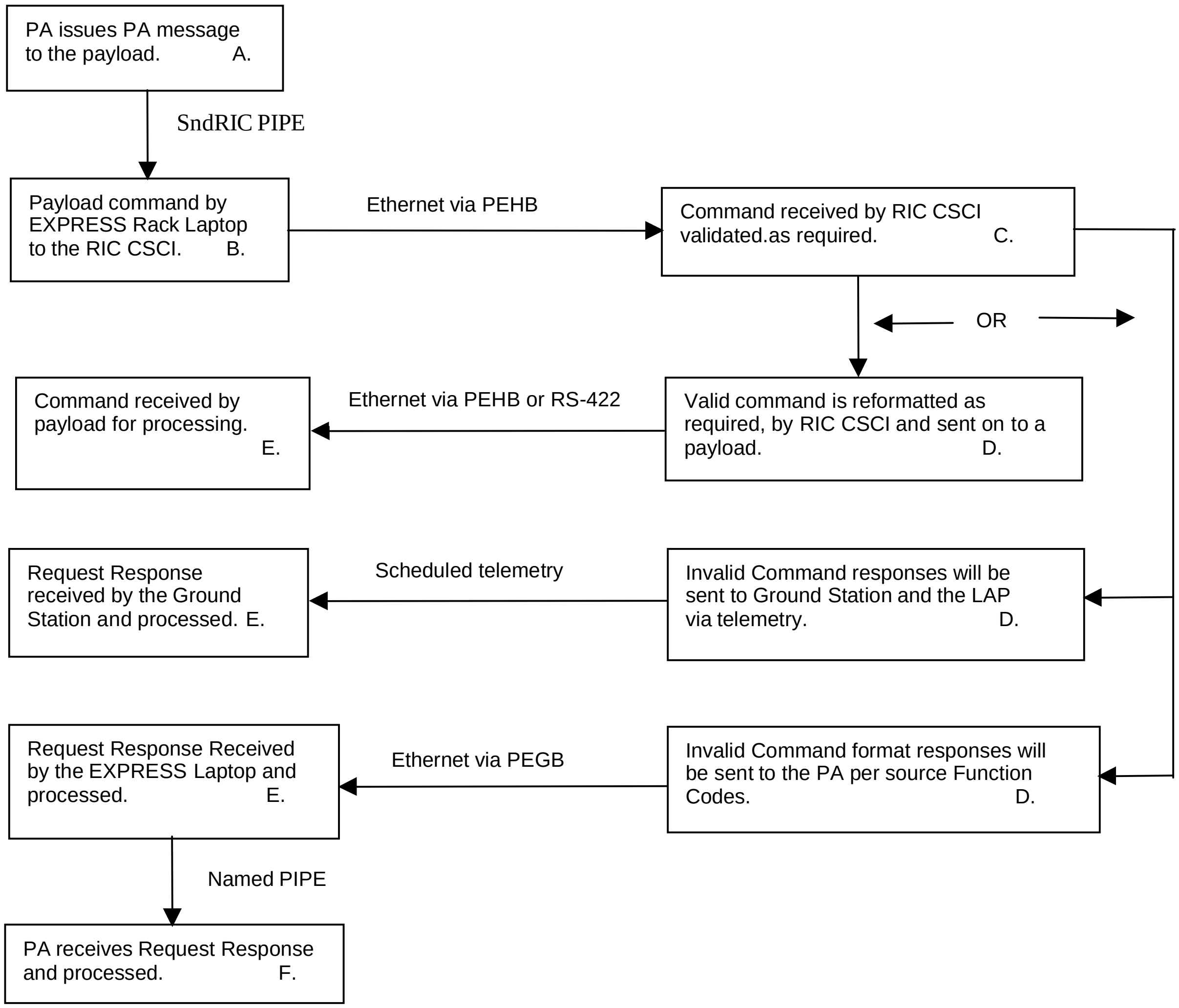


FIGURE 11-1 EXPRESS LAPTOP PAYLOAD COMMAND FLOW

flows from a payload to the PEP. The following paragraph provides information on each interface for the payloads (Ethernet, EIA/RS-422, EXPRESS laptop).

The EXPRESS RIC expects data with most significant byte first and least significant byte last and the word order is most significant word first and least significant word last.

A sync word, required for every message between the RIC and payload for both RS-422 and Ethernet interface, is used to identify the beginning of a new packet. Once the sync word is identified, the RIC uses the Message Byte Count in the EXPRESS Header to verify the size of each packet. If the sync word is not found, the RIC will discard the packet

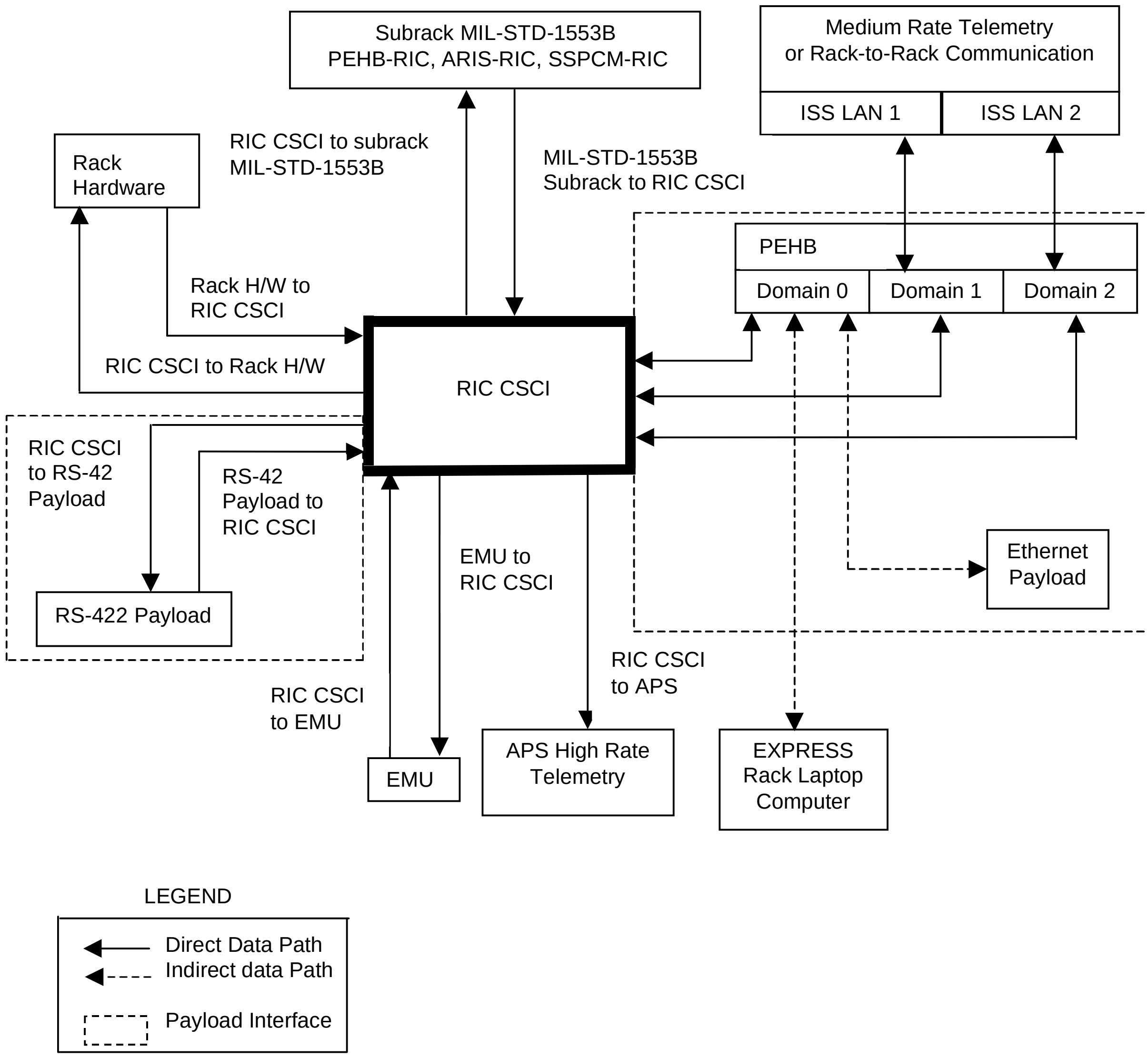


FIGURE 11-2 EXPRESS RIC CSCI INTERFACE DIAGRAM FOR RIC-TO-PAYLOADS AND OTHER RACK HARDWARE ITEMS

TABLE 11-I EXPRESS RACK PAYLOAD RELATED RIC CSCI EXTERNAL INTERFACE IDENTIFICATION

NAME	DESCRIPTION	INTERFACE TYPE
RS-422 PLD to RIC CSCI	Status, service requests, and data sent from payload via TIA/EIA-422.	Software
RIC CSCI to RS-422 PLD	Request and data sent to a payload via TIA/EIA-422.	Software
RIC CSCI to Ethernet PEHB Domain “0”	Request and data sent to a payload and laptop via Ethernet.	Software
Ethernet PEHB Domain “0” to RIC CSCI	Status, service requests, and data sent from payload and laptop via Ethernet to the RIC.	Software

and search again for a sync word and corresponding correct packet size which matches the Message Byte Count in the EXPRESS Header. In messages from the RIC to the payload, the RIC adds the sync word prior to sending each message to the payload. Upon receipt of a payload message by the RIC, the RIC removes the sync word prior to further processing.

The value of the Header Version as part of the first word of the EXPRESS Header is "0000" for the current version. The Message Byte Count is calculated by summing the number of bytes from Message Type to the last message data byte but not including the RS-422 serial checksum word. The Message Type is used by the RIC to identify the command/data/status contained in the message. The Function Code (source or destination) is used by the RIC to route each message for each interface in the rack. Words 2 to 4 of EXPRESS Header and EXPRESS telemetry secondary header are in 16-bit integer format. The RIC processes each message based on the Function Code and the Message Type in the EXPRESS Header.

For data/messages the RIC checks the EXPRESS Header. If the header format is incorrect, the message will be discarded and no retransmission will be requested. For commands, an invalid command status will be sent to the EXPRESS laptop and the ground if the header is incorrect.

11.2.1 EXPRESS Rack PEHB Interface (Ethernet)

The Ethernet connections for which the payload shall be compatible are IEEE-STD-802.3, Carrier Sense Multiple Access with Collision Detection Local Area Network Specification, Type 10BASE-T compliant. The RIC CSCI interfaces to the PEHB (Figure 11-2), in accordance with ANSI/IEEE-STD-802.3 Ethernet, for downlink of payload medium rate telemetry, communications with the EXPRESS Rack laptop CSCI, and communications with the payloads. Payload requiring a HRDL can access this interface via the PEHB to the RIC and then to the ISS Automated Payload Switch (APS). Ethernet-to-Ethernet or RS-422-to-Ethernet communication in the same or different racks is via the PEHB.

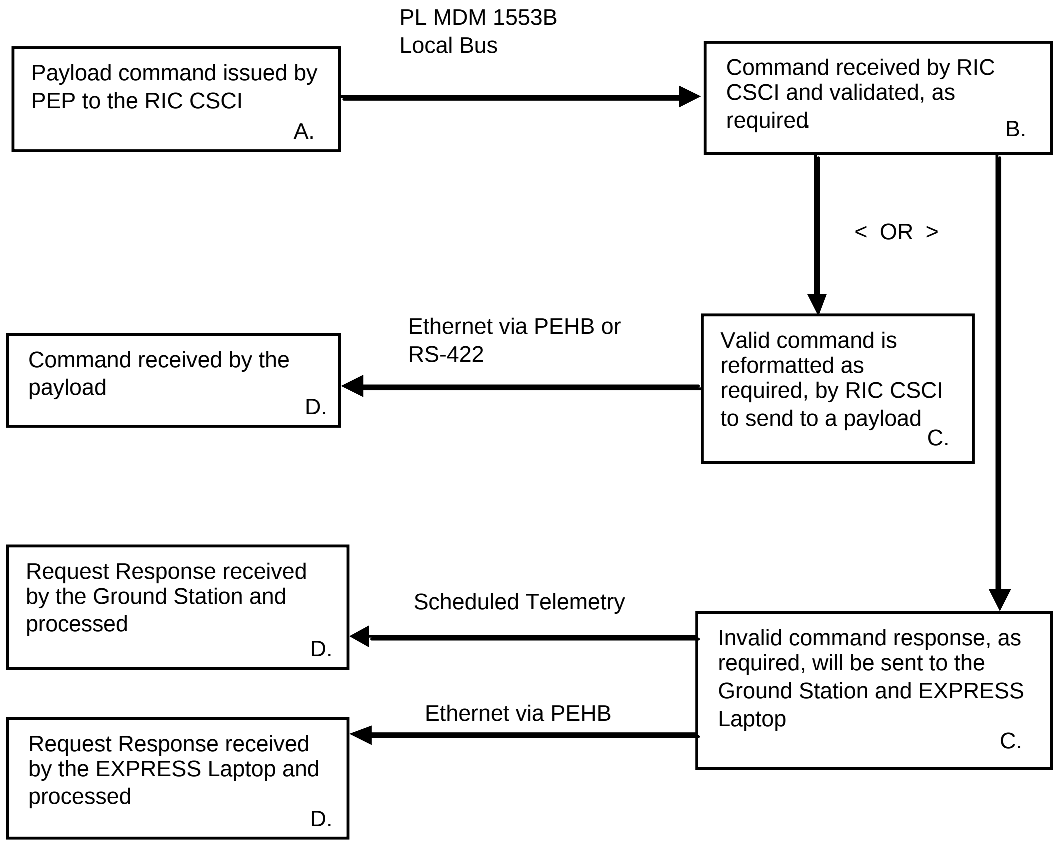


FIGURE 11-3 PAYLOAD PEP COMMAND

PEHB Ethernet interfaces for software are listed below:

A. ISS Payload Ethernet Hub/Gateway Interfaces

There is no direct physical interface between the RIC CSCI and the ISS LAN 1 and ISS LAN 2; however, there is an ANSI/IEEE-STD-802.3 Ethernet connection between the PEHB and the ISS LAN 1 and 2, which provides a logical Ethernet communications interface between the RIC CSCI and the ISS LAN 1 and 2 through the PEHB, that is used for downlink of medium rate telemetry and rack-to-rack communications (see Figure 11-2). A logical connection also exists between the Ethernet payloads and ISS LAN 1 and ISS LAN 2 through the PEHB.

B. Laptop Ethernet Interface

There is no direct physical interface between the RIC CSCI and the EXPRESS Rack laptop CSCI; however, there is an ANSI/IEEE-STD-802.3 Ethernet connection

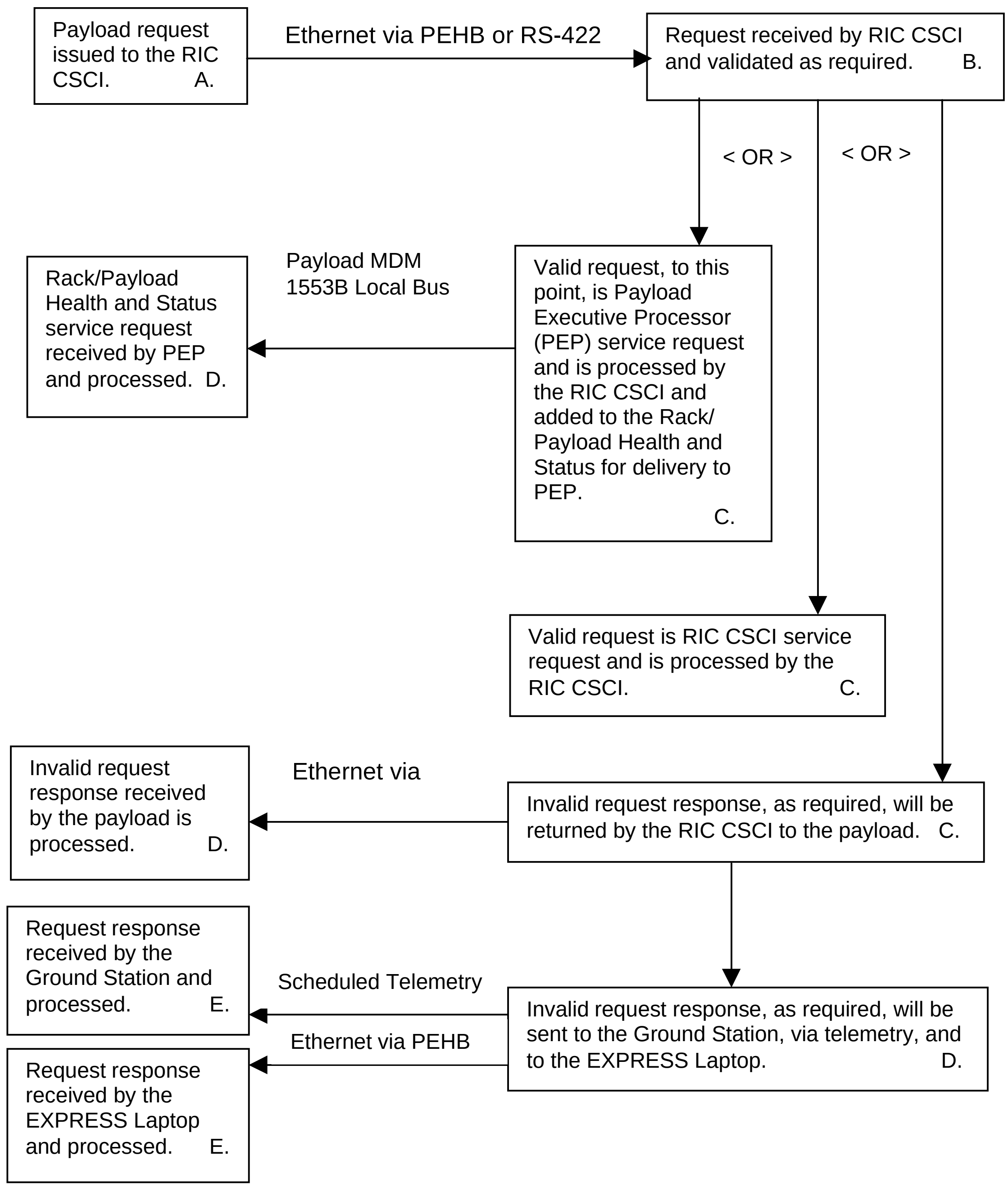


FIGURE 11-4 END-TO-END SERVICE REQUEST FOR PAYLOAD FLOW

between the PEHB and the EXPRESS Rack laptop, which provides a logical Ethernet communications interface between:

(1) The RIC CSCI and the EXPRESS Rack laptop CSCI through the PEHB, with communication in accordance with TCP/IP, for normal operations.

(2) The payloads and the EXPRESS Rack laptop CSCI through the PEHB will be used for payload data and file transfers in accordance with TCP/IP.

C. Payload Ethernet Interface

There is no direct physical Ethernet interface between the RIC CSCI and the payloads; however, there is an ANSI/IEEE-STD-802.3 Ethernet connection between the PEHB and the payloads, which provides a logical Ethernet communications interface between:

(1) The RIC CSCI and the payloads through the PEHB, with communication in accordance with TCP/IP Ethernet transmission protocol.

(2) The payloads and the ISS LAN 1 and ISS LAN 2 via PEHB and RIC will be used for rack-to-rack communications.

(3) The EXPRESS Rack laptop CSCI will be used for payload application data and file transfers.

The data and files elements for the payload Ethernet interfaces with which payload shall comply are shown in Table 11-II. The payload interface with the RIC by Ethernet shall be Ethernet TCP/IP protocol. The TCP/IP is supported by the RIC embedded VxWorks, version 5.3, operating system. The VxWorks network supports the associated Internet

Control Message Protocol and the Ethernet Address Resolution Protocol as implemented in UNIX Berkeley Software Distribution (BSD), version 4.3 (UNIX is a trademark of X/Open Ltd.) VxWorks Programmers Guide, version 5.1, VxWorks Reference Manual, version 5.1. The Ethernet is IEEE-STD-802.3 10 BASE-T format. The PEHB provides the isolation between the ISS network and the RIC/payloads. The TCP/IP header structure as described in Figure 9-2, is standard Berkley 4.3 with five 32-bit TCP header words and five 32-bit IP header words.

The IP address is assigned by the EXPRESS EI in the Ethernet Serial Data Description Form after the PD promotes the C&DH Data Set within the Payload Data Library. Once assigned, the IP address remains with the payload even if the payload is moved to another rack location. The TCP/IP port number within the range of 6212 to 6999 is assigned by the EXPRESS EI.

TABLE 11-II PAYLOAD ETHERNET EXTERNAL INTERFACE DATA ELEMENT (8)

DESCRIPTION	SOURCE	DESTINATION	FREQUENCY	DATA FORMAT
Ethernet PLD to RIC				
Payload Health and Status	PLD	RIC	1 Hz	Ethernet
PEP Bundle Request	PLD	RIC	Async	Ethernet
PEP Procedure Execution Request	PLD	RIC	Async	Ethernet
Rack Time Request	PLD	RIC	Async	Ethernet
Ancillary Data Config Control	PLD	RIC	Async	Ethernet
Payload Telemetry Downlink Data	PLD	RIC	Async	Ethernet
EMU File Transfer Request	PLD	RIC	Async	Ethernet
PLD File Transfer Data Block	PLD	RIC	Async	Ethernet
PLD File Transfer Request	PLD	RIC	Async	Ethernet
RIC to Ethernet Payload				
Ancillary Data Set	RIC	PLD	Async, .1, 1 Hz	Ethernet
Broadcast Ancillary Data Packet	RIC	PLD	10 Hz	Ethernet
Rack Request Response	RIC	PLD	Async	Ethernet
Rack Time Response	RIC	PLD	Async	Ethernet
EMU File Transfer Request	RIC	PLD	Async	Ethernet
PLD File Transfer Request	RIC	PLD	Async	Ethernet
PLD File Transfer Data Block	RIC	PLD	Async	Ethernet

The RIC is the client and payload is the server for all communication between the RIC and payload. For communication between the EXPRESS laptop and the RIC or payload, the EXPRESS laptop is the client and the RIC or payload is the server. The client establishes communication and afterwards maintains an open connection. If the connection is lost, the client deletes the current socket and creates a new socket. The server needs to reset the connection. Communication between the RIC and payload or between the EXPRESS laptop and a payload are 2-way transfer.

The RIC does not use the Ethernet address in processing. The Ethernet address of the payload is used to configure the PEHB Content Addressable Memory (CAM) addresses for communication to another payload outside the rack. The payload Ethernet address will be input to the PDL C&DH Data Set, Ethernet Serial Data Description Form, by the PD.

11.2.2 EXPRESS Rack RIC Serial Interface (RS-422)

The RIC CSCI interfaces to payloads requiring a serial interface as described in TIA/EIA-422-B-1994, Electrical Characteristics of Balanced Voltage Digital Interface Circuits. The data elements for this interface with which payloads shall comply are shown in Table 11-III. Note: Only if a request is invalid will a response be sent to the payload making the request. The request response will be returned within 1 sec of validation of the request except for requests to the PEP. The payload interface to the RIC by RS-422 format shall have a serial checksum at the end of each data message. The sync word in front of the EXPRESS Header is used in the communication protocol for RS-422 to indicate the beginning of a new message. The content from the first word of EXPRESS Header through the word before the serial checksum word is the payload message. When the RIC receives Health and Status, payload telemetry, or payload files, the RIC removes the sync word and the serial checksum word prior to further processing. When a payload command, Time response, Ancillary data, Request Response, or file comes from the PEP, the RIC adds the sync word at the beginning and the serial checksum word at the end before sending it to the payload. The EXPRESS serial checksum word is used only by the RIC and is computed as the sum, with no carry, of all message bytes including the sync word but excluding the checksum word itself. No flow control is used in the RS-422 interface.

Packets shall be separated by a minimum idle time equivalent to 5 data characters. Idle time consists of a period of time when no data is present on the interface. The messages shall be complete and contiguous (must never have idle time of more than two contiguous characters between sync word and message checksum word).

Note: The RS-422 checksum word is the summation of all bytes, starting with and including the sync word (55AA) but not including the checksum, with no carry (over the word boundary).

As an example, a payload with Function Code “100” requesting time from the RIC would send the message “55AA 0006 004D 0100 0001 0154” with a checksum of “0154h”.

55AA = Sync word

0006 = Version and Byte Count

004D = Message Type

0100 = Source Function Code (Payload)

0001 = Destination Function Code (RIC)

0154 = Checksum word (Sum of bytes from 55 + AA + 06 + 00 + 4D + 01 + 00 + 00 + 01)

TABLE 11-III PAYLOAD RS-422 EXTERNAL INTERFACE DATA ELEMENT (7)

DESCRIPTION	SOURCE	DESTINATION	FREQUENCY	DATA FORMAT
RS-422 Payload to RIC				
PEP Bundle Request	PLD	RIC	Async	RS-422
PEP Procedure Execution Request	PLD	RIC	Async	RS-422
Payload Health and Status	PLD	RIC	1 Hz	RS-422
EXPRESS Telemetry Downlink Data	PLD	RIC	Async	RS-422
Rack Time Request	PLD	RIC	Async	RS-422
Ancillary Data Config Control	PLD	RIC	Async	RS-422
EMU File Transfer Request	PLD	RIC	Async	RS-422
PLD File Transfer Request	PLD	RIC	Async	RS-422
PLD File Transfer Data Block	PLD	RIC	Async	RS-422
RIC to RS-422 Payload				
Ancillary Data Set	RIC	PLD	Async, .1, 1 Hz	RS-422
Broadcast Ancillary Data Packet	RIC	PLD	10 Hz	RS-422
Rack Request Response	RIC	PLD	Async	RS-422
Rack Time Response	RIC	PLD	Async	RS-422
EMU File Transfer Request	RIC	PLD	Async	RS-422
PLD File Transfer Request	RIC	PLD	Async	RS-422
PLD File Transfer Data Block	RIC	PLD	Async	RS-422

11.2.3 Payload Interface Data Elements

11.2.3.1 EXPRESS Header

Table 11-IV defines the header word format which shall be used during communications between the payload and the EXPRESS CSCI across the physical TIA/EIA-422 interface or across the logical Ethernet interface through the PEHB. Requests to the RIC can originate from the PEP (Command from Ground Station), laptop, or in a very few cases, a payload. The data types for the parameters in the EXPRESS Header are 16-bit integer. The only exception is that the first word (16-bit integer) of the EXPRESS Header will be divided to one 4-bit integer (Header Version) and one 12-bit integer (Message Byte Count). EXPRESS header including Version (0000h), Message Byte Count (sum of the bytes from Message Type to the last message data byte, but not including the RS-422 checksum word),

TABLE 11-IV EXPRESS HEADER (110)

<table>
<tr><td>MSB</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>LSB</td></tr>
<tr><td colspan="4">Header Version (4 bits)</td><td colspan="12">Message Byte Count (12 bits)</td></tr>
<tr><td colspan="16">Command Message Type/Measurement Message Type</td></tr>
<tr><td colspan="16">Function Code (Source)</td></tr>
<tr><td colspan="16">Function Code (Destination)</td></tr>
<tr><td colspan="16">Message Byte Count = Total Remaining Bytes in associated message, excluding Serial Checksum Words where applicable</td></tr>
</table>

Message Type (RIC unique identifier for the command/data/status contained in the message), Function Code (source or destination) unique Function Code for each interface.

11.2.3.2 Unique Identifier Numbers

The payload Subset ID for Health and Status, Function Code, TCP port number, and IP Address for TCP/IP will be assigned in PDL by EXPRESS EI after the PD promotes the C&DH Data Set. The telemetry APID is assigned in PDL by Payload Engineering Integration (PEI). Paylaods using the Ethernet interface use a subnet mask of 255.255.0.0. The payload's Ethernet port number is 6215. Payloads application resident on the EXPRESS Rack laptop will use the specific EXPRESS Rack laptop's IP address (obtained from EXPRESS Rack EI) with unique port number (assigned within the C&DH data set in PDL).

A unique Function Code is assigned to each payload software application and payload interface and is used by the RIC for communication with the payload. For a payload with both RS-422 and Ethernet interfaces in a single MDL or ISIS location, only one interface will be accessed by the RIC at a time. Change of the interface requires an update to the Rack Configuration File Format table in the RIC which involves shutdown of the payload. For multiple locker or drawer payloads, it is possible to interface to an RS-422 interface in one locker/drawer and an Ethernet interface in another locker/drawer. An additional Function Code would be assigned for the second interface. Table 11-V defines Function Codes for payloads, RIC, and Ground Station.

TABLE 11-V FUNCTION CODE ASSIGNMENTS (111)

RACK LOCATION/FUNCTION	ASSIGNMENT
RIC	0001 h
Ground Station	000F h
Individual PLD/PA	0010 h - FFFE h
ALL PLD (Broadcast within Rack)	FFFF h

11.2.3.3 EXPRESS Telemetry Header

The EXPRESS telemetry header is contained within the data field of the EXPRESS packet and subsequently the CCSDS user data field when downlinked. This header identifies the type of telemetry, and optionally, sequence count, and time tag. The format of the EXPRESS telemetry header which shall be used by payloads is presented in Table 11-VI.

TABLE 11-VI EXPRESS TELEMETRY SECONDARY HEADER (115)

MSB															LSB
Telemetry Data Type															
Sequence Count (Per Telemetry Data Type)[1]															
Time Tag (Most Significant Bit (MSB) of Coarse Time)[1]															
Time Tag (Least Significant Bit (LSB) of Coarse Time, LSB = 1 second)[1]															
[1]RIC generated telemetry will use as shown. Payload usage is optional; however, it is suggested this format be used for PLDs needing to rebuild messages on the ground.															

11.2.3.4 Payload Telemetry Packet

The payload downlink telemetry packet shall include the EXPRESS Header, EXPRESS telemetry secondary header, and payload telemetry data. The sync word will be in front of the EXPRESS Header, but is not part of the telemetry message. For an RS-422 payload, the serial checksum word will be at the end of the packet.

For a downlink telemetry packet, the destination Function Code is the RIC (0001h), and the Message Type is 009Ch in the EXPRESS Header. The first word of the EXPRESS telemetry secondary header (telemetry Data Type) along with the Function Code in the EXPRESS Header is used by the RIC to identify the telemetry APID on Telemetry Configuration File Format for use in construction of the CCSDS header. The HOSC uses the Data Type as the Format ID. The telemetry Data Type can be any value between 0 and 65535. The RIC can handle up to six data types per payload: one for the default pass (FFFF) and five for exception passes based on the telemetry Data Type. The Sequence Count and Time Tag (two words) in the EXPRESS telemetry secondary header are recommended but are optional.

Telemetry can be of variable length. The maximum size of each packet is 1,248 data bytes plus the sync word, the EXPRESS Header, and the EXPRESS telemetry secondary header. To select the telemetry downlink channel via either low rate, medium rate, or the high rate, the PD submits the selection in the PDL C&DH Data Set Downlink Telemetry Data Packets form which will be incorporated into the Telemetry Configuration File Form. The RIC does not send a response if telemetry data is sent while the link is not available. The RIC simply collects and forwards the data for downlink during the periods of time when the telemetry link is available. All telemetry data sent while the link is not available is discarded. More than one telemetry APID may be assigned to a single payload, depending on requirements.

The payload telemetry rate is entirely dependent on the rate the payload transmits the telemetry to the RIC and the downlink resources available to the RIC. Payload telemetry received from a payload that exceeds the RIC resources to downlink or comes from a payload that does not have an entry in the Telemetry Configuration table will be discarded. The EXPRESS laptop and Ground Station are notified of data loss through an increase in the data lost count in the EXPRESS Rack Health and Status data. When a valid payload message is received but the telemetry path designated in the Telemetry Configuration tables has not been activated using the Downlink Configuration Control command to the RIC, a Payload Response will be sent to the payload. The invalid response will be reported to the Ground Station and the EXPRESS laptop. The Downlink Configuration Control table is used to notify the RIC to start or stop the telemetry service. When the payload input is less than the minimum telemetry data size, the RIC will fill at the end of the packet to meet the minimum length requirement.

For a payload telemetry packet, the RIC verifies the EXPRESS Header and the telemetry Data Type in the EXPRESS telemetry secondary header. For an Ethernet telemetry packet, the RIC removes the sync word, adds the CCSDS header in front of the EXPRESS Header, and sends the message to the designated channel per the Telemetry Configuration File in the RIC. For an RS-422 payload telemetry packet, the RIC removes the sync word and the serial checksum word and adds the CCSDS header before sending the message out. Table 11-VII defines the telemetry data packet (including the header) which shall be used by the payload. The CCSDS time generated by the RIC (word 4 and 5 of CCSDS header) is two days behind the present date, this problem will be corrected in the future EXPRESS Rack RIC software releases.

11.2.3.5 EXPRESS RIC Interface Requests and Responses

Six types of request for RIC or PEP services that can be made by payloads are PEP Bundle Request, PEP Procedure Execution Request, Rack Time Request, Ancillary Data Configuration Control, Payload File Transfer Request, and EXPRESS Memory Unit (EMU) Payload File Transfer Request. PEP-related requests**,** originating from the Ground Station, EXPRESS laptop, or the payload are sent to the PL MDM via the EXPRESS Rack Health and Status data. Figure 11-4 defines the end-to-end flow of the payload service request. Tables 11-VIII and 11-IX define the requests and messages between the EXPRESS payloads and RIC CSCI. The table consists of the header/message/word definitions that shall be used by payload. Table 11-VIII contains the request message types. Table 11-IX contains PL/Payload Application (PA) message definition and payload request responses data message types.

TABLE 11-VII EXPRESS TELEMETRY PACKET FORMAT (118)

MSB														LSB
SYNC (55AA)														
EXPRESS Header														
EXPRESS Telemetry Secondary Header														
Data Byte 1							Data Byte 2							
Data Byte 3							Data Byte 4							
• • •														
Data Byte n-1							Data Byte n (maximum Ethernet n = 1248 Data Bytes maximum TIA/EIA-422 n = 1248 Data Bytes)							
EXPRESS serial checksum word (only applicable for TIA/EIA-422 messages between the RIC and payloads. Consists of the sum, with no carry, of all message bytes, including Sync Word, prior to the EXPRESS Serial Checksum word).														

TABLE 11-VIII REQUEST MESSAGE TYPE ASSIGNMENTS/LOCATION (120)

MESSAGE TYPE		FUNCTION CODE	
DESCRIPTION	ASSIGNMENT	SOURCE	DESTINATION
Request Messages			
PEP Bundle Request	0049 h	GS, LAP, PLD	RIC
PEP Procedure Execution Request	004C h	GS, LAP, PLD	RIC
Rack Time Request	004D h	GS, LAP, PLD	RIC
Ancillary Data Configuration Control	0020 h	GS, LAP, PLD, PA	RIC
PLD File Transfer Request	0041 h	PLD, RIC	RIC, PLD
EMU File Transfer Request	0042 h	GS, LAP, PLD	RIC
NOTE: When referring to Ground Stations (GS) commanding: ALL commanding from the Ground Stations or the ISS must come through the PEP and be formatted using valid EXPRESS headers. Because of this, no distinction is made on where a command originates from outside the EXPRESS Rack.			

11.2.3.5.1 PEP Bundle Request

The PEP bundles contain groups of Timeliner Procedures (Sequences) that are to be automatically executed on the PL MDM. It could consist of monitoring parameters, issuing messages, issuing commands (at a specific time, or after a specific time delay if desired, etc.). The purpose of the PEP Bundle Request is to request a bundle of Timeliner commands on the

TABLE 11-IX STATUS MESSAGE TYPE ASSIGNMENTS/LOCATION (121)

MESSAGE TYPE		FUNCTION CODE	
DESCRIPTION	ASSIGNMENT	SOURCE	DESTINATION
Rack Responses			
Rack Time Response	0080 h	RIC	LAP, PLD
PLD, PA Request Response	0082 h	RIC	PLD, PA
Ancillary Data Set	0098 h	RIC	PLD, PA
Broadcast Ancillary Data Set	0099 h	RIC	PLD, PA
Payload Health and Status	009B h	PLD	RIC
EXPRESS Telemetry Packet	009C h	PLD	RIC
PLD File Transfer data Block	00A4 h	PLD, RIC	RIC, PLD
Rack Analog and Discrete Data	00B0 h	LAP	PA
NOTE: When referring to Ground Stations (GS) communications: Communications to the Ground Stations may be directed through the PEP (via Low Rate Telemetry (LRT), File Transfer or Health and Status), Medium Rate Telemetry, or High Rate Telemetry.			

PEP to be installed, halted, or removed. Table 11-X defines the format for the PEP Bundle Request. The Bundle Identifier Parameter is a unique integer value assigned by the PEP relating to the bundle of Timeliner commands stored on the PL MDM.

TABLE 11-X PEP BUNDLE REQUEST (191)

MSB															LSB
SYNC (55AA)															
EXPRESS Header (Message Type = 0049 h)															
PEP Request Identifier: (Integer value) 21 = Install, 22 = Halt, 23 = Remove															
Bundle Identifier Parameter: (Unique value relating to a User Interface Language (UIL) Bundle assigned by PEP)															

11.2.3.5.2 PEP Procedure Execution Request

The purpose of the PEP Procedure Execution Request is to request a Timeliner sequence on the PEP to be started, stopped, or resumed. Table 11-XI defines the format for the PEP Procedure Execution Request. The Payload Dependent Sequence Identifier is a unique integer value, assigned by the PEP, relating to the Timeliner sequence stored on the PL MDM. The procedures are compiled into the bundles using the compiler for Timeliner.

TABLE 11-XI PEP PROCEDURE EXECUTION REQUEST (194)

MSB														LSB
SYNC (55AA)														
EXPRESS Header (Message Type = 004C h)														
Request Identifier: (Integer value) 18 = Start, 19= Stop, 20 = Resume														
Payload Dependent Sequence Identifier: (Unique integer value relating to the sequence assigned by PEP)														

Once the appropriate Timeliner files are on the PL MDM, commands may be issued to the Timeliner (or requested of the PL MDM by a payload) for the execution of those procedures.

11.2.3.5.3 Rack Time Request

The purpose of the Rack Time Request, with format as defined in Table 11-XII, is to request the current PEP time broadcast. The requesting source is identified by the source Function Code in the EXPRESS Header. In response to the Rack Time Request the RIC distributes the PEP Broadcast time in the format described in the Rack Time Response Table 11-XIII. The RIC time response will be based on the last broadcast time received from the PL MDM. The time is updated every 30 seconds or, based on the update rate, as requested by the payload (in minutes) in the Rack Configuration Control table. If the payload requires an update more frequently than once every 30 seconds, the payload can send a request to the RIC and the RIC will respond immediately.

TABLE 11-XII RACK TIME REQUEST (134)

MSB														LSB
SYNC (55AA)														
EXPRESS Header (Ref. Table 11-IV) (Message Type = 004D h)														

11.2.3.5.4 Ancillary Data Configuration Control

The purpose of this command is to request Ancillary data set or Broadcast ancillary frame routing or to request aperiodic ancillary data set routing. The Ancillary Data Configuration Control can come from the Ground Station, EXPRESS laptop, or payload. After the request is validated, the ancillary data configuration is updated. A request is then sent to the PEP to acquire the requested ancillary data set. Invalid responses will be reported to the Ground Station, EXPRESS laptop, or payload in response to command (request)

TABLE 11-XIII RACK TIME RESPONSE (137)

MSB															LSB
EXPRESS Header (Message Type = 0080 h)															
CCSDS Preamble Field ='01010000'B								MSB of BCD Year Field (19-20)							
LSB of BCD Year Field (0-99)								BCD Month Field (1-12)							
BCD Day of Month Field (1-31)								BCD Hour Field (0-23)							
BCD Minutes Field (0-59)								BCD Seconds Field (0-59)							
Spare - 000 h												Binary Sub-seconds high (0-15) [1]			
Binary Sub-seconds Low (0-65535) [1]															
Universal Time Coordinate (UTC) Time Conversion Parameter (0-65535) Always set to zero. Note this data is contained in Broadcast Ancillary Data															
Non-CCSDS Seconds/sub-seconds (0-65535) The one's portion of the seconds plus the sub-seconds information of the CCSDS time converted to a straight binary count rounded to the nearest 256 microsecond (LSB = 256 microsec)															
[1] **Combining sub-second high and sub-second low, the total range is 0 - 1048560 at one microsecond per count.**															

validation. The PEP can deliver up to 10 UAD (Unique Ancillary Data) set per second. The RIC can deliver up to 10 messages with a combination of Ancillary data sets or Broadcast Ancillary data frames per second.

The Request ID specifies whether to add or delete the ancillary data configuration entry associated with the Data Set ID and Function Code in the request from the Ancillary Configuration table, Table 11-XIV. If the Request ID is an Aperiodic Request, the ancillary data set will be requested once (one shot) and the Ancillary Configuration table will not be changed. The Ancillary Configuration table only consists of cyclically required Ancillary data sets shown in Table 11-XV.

The Data Set ID/Frame Number specifies the Ancillary data set or Broadcast ancillary data frame to be acquired for the Function Code.

The payload will receive the Broadcast Ancillary data with 64 words per packet shown in Table 11-XVI. Each packet includes a CCSDS header (the first 8 words), 36 words of 1-Hz data, and 20 words of 0.1-Hz data. It takes 10 sec to complete the transmission of the Broadcast Ancillary Data Set. For de-coding Broadcast Ancillary data set word messages, reference SSP 41175-2. It is recommended that payloads receiving Broadcast Ancillary data frames check the Frame ID (least 7 significant bits of the CCSDS header word 8) before further processing.

TABLE 11-XIV ANCILLARY DATA CONFIGURATION CONTROL (140)

MSB															LSB
SYNC (55AA)															
EXPRESS Header (Message Type = 0020 h)															
Destination Function Code (Destination of the Ancillary Data)															
Spare (00 b) (2 bits)		Request Identifier[1] (2 bits)		Spare (0 h) (4 bit)				Data Set Identifier/Frame Number[2] (8 bits)							

NOTES:

1. Request Identifier: 00 b = Aperiodic (One shot) Request (no change to Ancillary Configuration Table and does not apply to Broadcast Ancillary Data Frame)
   01 b = Add Entry, 11 b = Delete Entry
2. Data Set Identifier: 01 h - 64 h = thru 100 Ancillary Data Sets ID for Ancillary Data,
   Frame Number: 80 h - E3 h = 0 thru 99 Frame Number for Broadcast Ancillary Data,
   E4 h all frames of Broadcast Ancillary Data to PLD
   FF h = Unused Data Set Identifier or Frame Number

TABLE 11-XV ANCILLARY DATA SET (144)

MSB															LSB
SYNC (55AA)															
EXPRESS Header (Message Type = 0098 h)															
Spare (0 h) (8 bits)								Data Set Identifier[1] (8 bits)							
Ancillary Data Set Word 1															
• • •															
Ancillary Data Word n (Maximum of 23)															
[1]Data Set Identifier: 01 h - 64 h = 1 thru 100 Ancillary Data Sets															

11.2.3.5.5 File Transfer

A payload can send a request for file transfer service to the RIC. The file transfer types are payload to EMU, EMU to payload, and EMU to the Ground Station. The request shall include the EXPRESS Header and File name.

11.2.3.5.5.1 Payload File Transfer

The Payload File Transfer Request command provides the capability for a payload to request a file transfer between the payload and the RIC EMU. The format for the Payload File Transfer Request is shown in Table 11-XVII.

TABLE 11-XVI BROADCAST ANCILLARY DATA SET (145)

<table>
<tr><th>Field ID</th><th>Word #</th><th>MSB</th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th>LSB</th></tr>
<tr><td colspan="18">SYNC (55AA)</td></tr>
<tr><td rowspan="4">EXPRESS Header</td><td>1</td><td colspan="4">Header Version</td><td colspan="12">Message Byte Count</td></tr>
<tr><td>2</td><td colspan="16">Message Type = 0099 h</td></tr>
<tr><td>3</td><td colspan="16">Function Code (source)</td></tr>
<tr><td>4</td><td colspan="16">Function Code (destination)</td></tr>
<tr><td rowspan="3">Primary CCSDS Header</td><td>1</td><td colspan="3">Version #</td><td>Type</td><td>Sec Hdr Flag</td><td colspan="11">APID (11 bit field)</td></tr>
<tr><td>2</td><td colspan="2">Seq Flags</td><td colspan="14">Packet Sequence Count (14 bits)</td></tr>
<tr><td>3</td><td colspan="16">Packet Length (# octets - 1 following this field)</td></tr>
<tr><td rowspan="5">Sec CCSDS Header</td><td>4</td><td colspan="16">Time (MSBs of Course time)</td></tr>
<tr><td>5</td><td colspan="16">Time (LSBs of Course Time, LSB = 1 second)</td></tr>
<tr><td>6</td><td colspan="8">Fine Time</td><td colspan="2">Time ID</td><td>Chec word</td><td>Spare</td><td colspan="4">Packet Type</td></tr>
<tr><td>7</td><td>Spare</td><td colspan="4">Element ID</td><td>1</td><td colspan="4">Version ID</td><td colspan="6">Format ID</td></tr>
<tr><td>8</td><td colspan="9">Spare 9 bit Field</td><td colspan="7">Frame ID (7 bit field)</td></tr>
<tr><td>1 Hz Area</td><td>9 to 44</td><td colspan="16">Broadcast Ancillary Data Word</td></tr>
<tr><td>0.1 Hz Area</td><td>45 to 64</td><td colspan="16">Broadcast Ancillary Data Word</td></tr>
<tr><td colspan="18"></td></tr>
</table>

The source Function Code in the EXPRESS Header identifies the payload making the Payload File Transfer Request. The Transfer Request Type identifies the type of RIC File Transfer Service requested. The available requests are File Transfer Start, File Transfer Stop, File Transfer Restart, and File Transfer Complete.

The File Transfer ID identifies the direction of the Payload File Transfer Request, either “payload to EMU” or “EMU to payload.” Only one file transfer in each direction (EMU to payload or payload to EMU) will be allowed to take place at any one time. The “PLD” directory will be used in all payload file transfer transactions.

The Filename is the name of the file being stored to or retrieved from the EMU. When the incoming Filename is new, the RIC commands the EMU to create a new Filename and store the data. When the Filename already exists on the EMU, the file will be overwritten by the new file of the same name. A valid Filename consists of 12 ASCII character bytes configured as follows:

A Filename of 0 to 8 case sensitive ASCII character bytes optionally followed by NUL (00 h) ASCII character bytes, or the period (2E h) delimiter ASCII character byte

TABLE 11-XVII PAYLOAD FILE TRANSFER REQUEST

<table>
<tr><td>MSB</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>LSB</td></tr>
<tr><td colspan="16">SYNC (55AA)</td></tr>
<tr><td colspan="16">EXPRESS Header
(Message Type = 0041 h)</td></tr>
<tr><td colspan="2">[1]</td><td colspan="2">[2]</td><td colspan="12">Reserved for RIC</td></tr>
<tr><td colspan="8">Filename [3] (character #1)</td><td colspan="8">Filename (character #2)</td></tr>
<tr><td colspan="8">Filename (character #3)</td><td colspan="8">Filename (character #4)</td></tr>
<tr><td colspan="8">Filename (character #5)</td><td colspan="8">Filename (character #6)</td></tr>
<tr><td colspan="8">Filename (character #7)</td><td colspan="8">Filename (character #8)</td></tr>
<tr><td colspan="8">Filename (character #9)</td><td colspan="8">Filename (character #10)</td></tr>
<tr><td colspan="8">Filename (character #11)</td><td colspan="8">Filename (character #12)</td></tr>
<tr><td colspan="16">Block Number to Restart</td></tr>
<tr><td colspan="16">[1] Transfer Request Type : ---------- 00 b = File Transfer Start, 01 b = File Transfer Stop,
10 b = File Transfer Restart------ 11 b = File Transfer Complete
[2] File Transfer ID: ---- 00 b = payload to EMU--------------------------- 01 b = EMU to payload
[3] The Filename is NUL (00 h) ASCII character byte filled on the end for any Filename plus extension less than 12 characters.</td></tr>
</table>

optionally followed by NUL ASCII character bytes, or an extension of 0 to 3 case sensitive ASCII character bytes followed by NUL ASCII character bytes. All payload files will be stored in the “PLD” directory on the EMU.

In all cases, the 12 ASCII character fields will have a contiguous set of character forming a valid Filename and will be (if required) end-filled with NUL ASCII character bytes. Valid Filename examples would include: filename.ext, f.e, file, .ex

The Block Number to Restart is used for restarting a File Transfer Read or Write at a specified block number.

The Payload File Transfer Request can only come from the payloads. Once validated and initiated, until the file transfer transaction has been terminated, ONLY the requesting payload is allowed to send further Payload File Transfer Requests of that specific File Transfer ID type (EMU to payload or payload to EMU). After successful validation:

For a “payload to EMU” transfer:

The RIC will set “payload-to-EMU File Transfer” status bit in EXPRESS Rack Health and Status to “In Progress.”

If upon file transfer transaction startup an error occurs in storing data to the EMU:

A. The RIC will send the originating Payload File Transfer Request back to that payload except the RIC will set the Transfer Request Type to “File Transfer Stop.”

B. The RIC will send a “EMU File Access Error” Rack Request Response to the EXPRESS laptop and Ground Stations, via telemetry.

C. The RIC will set the “payload-to-EMU File Transfer” status bit in the EXPRESS Rack Health and Status to “Not In Progress.”

The RIC will expect valid, contiguous Payload File Transfer Data Blocks to begin arriving from the requesting payload (Source Function code of the Payload File Transfer Request).

Upon receipt of a Payload File Transfer Data Block with the Current Block Number equal to the Total Block Number:

A. The RIC will send the originating Payload File Transfer Request back to that payload except the RIC will set the Transfer Request Type to “File Transfer Complete.”

B. The RIC will set the “payload to EMU File Transfer” status bit in the EXPRESS Rack Health and Status to “Not In Progress.”

Upon receipt of a Payload File Transfer Data Block with a noncontiguous Current Block Number, the RIC will send the originating Payload File Transfer Request back to that payload except the RIC will set the Transfer Request Type to “File Transfer Restart” and the ‘Block Number to Restart’ will be set to the correct contiguous Current Block expected.

The following conditions will cause the RIC to terminate the payload file transfer of “payload to EMU” ID at any time prior to receiving a Current Block Number equal to the Total Block Number:

If an error occurs in storing data to the EMU:

A. The RIC will send the originating Payload File Transfer Request back to that payload except the RIC will set the payload Request Type to “File Transfer Stop.”

B. The RIC will send a “EMU File Access Error” Rack Request Response to the EXPRESS laptop and Ground Stations, via telemetry.

C. The RIC will attempt to delete the portion of the payload file that has been stored on the EMU.

D. The RIC will set the “payload to EMU File Transfer” status bit in the EXPRESS Rack Health and Status to “Not In Progress.”

If a contiguous period of 10 sec passes by without the receipt of a valid Payload File Transfer Data Block from the valid payload source:

A. The RIC will send the originating Payload File Transfer Request back to that payload except the RIC will set the Transfer Request Type to “File Transfer Stop.”

B. The RIC will send a “Payload to EMU File Transfer Terminated” Rack Request Response to the EXPRESS laptop and Ground Stations, via telemetry.

C. The RIC will delete the portion of the payload file that has been stored on the EMU.

D. The RIC will set the “Payload to EMU File Transfer” status bit in the EXPRESS Rack Health and Status to “Not In Progress.”

If the RIC receives a Payload File Transfer Request with an ID of “Payload to EMU” and a Transfer Request Type of “File Transfer Stop”:

A. The RIC will delete the portion of the payload file that has been stored on the EMU.

B. The RIC will send a “Payload to EMU File Transfer Terminated” Rack Request Response to the EXPRESS laptop and Ground Stations, via telemetry.

C. The RIC will set the “Payload to EMU File Transfer” status bit in the EXPRESS Rack Health and Status to “Not In Progress,”

at any time prior to receiving a Current Block Number equal to the Total Block Number. If the RIC receives a valid Payload File Transfer Request with an ID of “Payload to EMU” and a Transfer Request Type of “File Transfer Restart” or “File Transfer Complete,” the RIC will ignore the request.

For an “EMU to Payload” transfer and a Transfer Request Type of “File Transfer Start” or a “File Transfer Restart” with a “Block Number to Restart”:

The RIC will set “EMU to Payload File Transfer” status bit in EXPRESS Rack Health and Status to “In Progress.”

Upon file transfer transaction startup an error in retrieving data from the EMU:

A. The RIC will send the originating Payload File Transfer Request back to that payload except the RIC will set the Transfer Request Type to “File Transfer Stop.”

B. The RIC will send a “EMU File Access Error” Rack Request Response to the EXPRESS laptop and Ground Stations, via telemetry.

C. The RIC will set the “EMU to Payload File Transfer” status bit in the EXPRESS Rack Health and Status to “Not In Progress.”

The RIC will start sending Payload File Transfer Data Blocks, reference Table 11-XVIII, to the requesting payload (Source Function code of the Payload File Transfer Request).

TABLE 11-XVIII PAYLOAD FILE TRANSFER DATA BLOCK

<table>
<tr><td>MSB</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>LSB</td></tr>
<tr><td colspan="16">SYNC (55AA)</td></tr>
<tr><td colspan="16">EXPRESS Header
(Message Type = 00A4 h)</td></tr>
<tr><td colspan="16">Current Block Number</td></tr>
<tr><td colspan="16">Total Block Number</td></tr>
<tr><td colspan="8">Data Byte #1</td><td colspan="8">Data Byte #2</td></tr>
<tr><td colspan="16">. . .</td></tr>
<tr><td colspan="8">Data Byte #n-1</td><td colspan="8">Data Byte #n
(where n <= 1248 bytes per block)</td></tr>
</table>

Upon sending the Current Block Number equal to the Total Block Number, the RIC will set the “EMU to Payload File Transfer” status bit in the EXPRESS Rack Health and Status to “Not In Progress.”

At any time prior to sending a Current Block number equal to the Total Block Number. If the RIC receives a valid Payload File Transfer Request with an ID of “EMU to Payload” and a Transfer File Type of “File Transfer Restart,” the RIC will find the correct “Block Number to Restart” of data and continue the file transfer transaction with the next block being sent having a Current Block Number equal to the “Block Number to Restart.”

The following conditions will cause the RIC to terminate the payload file transfer of “EMU to Payload” File Transfer ID at any time prior to sending a Current Block Number equal to the Total Block Number:

If an error occurs in retrieving data from the EMU:

A. The RIC sends the valid payload a Payload File Transfer Request with an ID “EMU to Payload” and a Transfer Request Type of “File Transfer Stop.”

B. The RIC will also issue a Rack Request Response of “EMU to Payload File Transfer Terminated” to the EXPRESS laptop and Ground Stations, via telemetry.

C. The RIC will set the “EMU to Payload File Transfer” status bit in the EXPRESS Rack Health and Status to “Not In Progress.”

The RIC receives a Payload File Transfer Request with an ID "EMU to Payload" and a Transfer Request Type of "File Transfer Stop":

A. The RIC will also issue a Rack Request Response of "EMU to Payload File Transfer Terminated" to the EXPRESS laptop and Ground Stations, via telemetry.

B. The RIC will set the "EMU to Payload File Transfer" status bit in the EXPRESS Rack Health and Status to "Not In Progress."

At any time prior to sending a Current Block Number equal to the Total Block Number, if the RIC receives a valid Payload File Transfer Request with an ID of "EMU to Payload" and a Transfer Request Type of "File Transfer Complete," the RIC will ignore the request.

The following invalid responses will be reported, in response to EXPRESS command validation:

The Request Responses will be sent to the EXPRESS laptop and Ground Stations via telemetry and to the requesting payload.

The Payload Response error codes are defined in Table 11-XXII.

The Payload File Transfer Data Block is the mechanism to transfer data between the RIC and payloads. The Table 11-XVIII defines the format for the Payload File Transfer Data Block.

All file transfers to and from the RIC will be staged on the EMU. The Payload File Transfer Data Block command allows the user to control these file transfers. File transfers between the EMU and the EXPRESS laptop will be accomplished under the EXPRESS laptop control using a standard File Transfer Protocol (FTP) mechanism. The RIC CSCI will not take part in this FTP file transfer.

The Current Block Number gives the block number of the Payload File Transfer Data Block. The maximum size of a Payload File Transfer Data Block is 1,248 data bytes. When the Payload File Transfer to be sent or received is larger than 1,248 data bytes, it will take multiple data blocks to complete the message.

The Total Block Number gives the number of Payload File Transfer Data Block message blocks which must be sent or received to complete the Payload File Transfer. Note that the maximum number of Payload File Transfer Data Blocks that can be sent are 65,535, or in other words, a single maximum file size of 81,787,680 data bytes in length can be transferred.

11.2.3.5.5.2 EMU File Transfer

Payloads also have the capability to issue EMU File Transfer Control commands to request a file transfer between the EMU and Ground Station. Table 11-XIX defines the format for the EMU File Transfer Control.

TABLE 11-XIX EMU FILE TRANSFER REQUEST

MSB															LSB
EXPRESS Header (Message Type = 0042 h)															
[1]		[2]		Reserved for RIC											
Directory (character #1)								Directory (character #2)							
Directory (character #3)								/ (2F h)							
Filename [3] (character #1)								Filename (character #2)							
Filename (character #3)								Filename (character #4)							
Filename (character #5)								Filename (character #6)							
Filename (character #7)								Filename (character #8)							
Filename (character #9)								Filename (character #10)							
Filename (character #11)								Filename (character #12)							
Payload Dependent File Identifier (Unique integer value relating to a file stored on the PLD MDM assigned by PEP)															
Block Number to Restart															

[1] EMU Request Type : --- 00 b = File Transfer Start, ------01 b = File Transfer Stop,
-------------------------------- 10 b = File Transfer Restart ----11 b = File Transfer Complete

[2] File Transfer ID:------10 b = EMU to Ground Station ------------------ 11 b = Reserved for RIC

[3] The Filename is NUL (00 h) ASCII character byte filled on the end for any Filename plus extension less than 12 characters.

For a File Transfer to Ground Station (for reading a file from the EMU and sending it to the configured Ground Station), the RIC CSCI will use the Telemetry Configuration table for establishing the telemetry path and APID.

The Directory identifies the EMU directory from which the file is being read.

The Filename is the name of the file being retrieved from the EMU. A valid Filename consists of 12 ASCII character bytes configured as follows:

A Filename of 0 to 8 case sensitive ASCII character bytes optionally followed by NUL (00 h) ASCII character bytes, or

The period (2E h) delimiter ASCII character byte optionally followed by NUL ASCII character bytes, or

An extension of 0 to 3 case sensitive ASCII character bytes followed by NUL ASCII character bytes

In all cases, the 12 ASCII character fields will have a contiguous set of characters forming a valid Filename and will be (if required) end filled with NUL ASCII character bytes. Valid Filename examples would include: filename.ext, f.e, file, .ex

In the case of an EMU to Ground Station transfer, the Block Number to Restart is not used and the complete file will be re-sent starting at Block 1.

The EMU File Transfer Requests will be accepted from the payloads, Ground Stations, or the EXPRESS laptop at any time. Successive commands will override previous commands as long as Directory, Filename, File Transfer ID, and Payload Dependent File Identifier (when required) are the same as the last valid command. After successful validation:

For a EMU to Ground Station (GS) file transfer and a Transfer File Type of "File Transfer Start":

The RIC will set "EMU to GS File Transfer" status bit in EXPRESS Rack Health and Status to "In Progress."

The RIC will retrieve the requested file from the EMU in 1248 data byte blocks.

A. If upon startup an error occurs in retrieving data from the EMU:

(1) The RIC will send a "EMU File Access Error" Rack Request Response to the EXPRESS laptop and Ground Stations, via telemetry.

a. And if a payload originated the EMU File Transfer Request message transaction, the RIC will send back to that payload the same EMU File Transfer Request message except the RIC will set the EMU Request Type to "File Transfer Stop."

(2) The RIC will set the "EMU to GS File Transfer" status bit in the EXPRESS Rack Health and Status to "Not In Progress."

Based on the Source Function Code of the EMU File Transfer Request and the appropriate telemetry configuration table:

A. The RIC will add an EXPRESS Header and EXPRESS Telemetry Secondary Header to each data block to create a Ground Station File Transfer Data Block. The source Function Code in EXPRESS Header will be the RIC when the command comes from the Ground Station or the EXPRESS laptop.

B. The RIC will add a CCSDS header and send the telemetry message down the scheduled telemetry transfer path.

Upon sending the Ground Station File Transfer Data Block with the Current Block Number equal to the Total Block Number, the RIC will set the “EMU to GS File Transfer” status bit in the EXPRESS Rack Health and Status to “Not In Progress.”

A. And, if a payload originated the EMU File Transfer Request message transaction, the RIC will send back to that payload the same EMU File Transfer Request message except the RIC will set the EMU Request Type to “File Transfer Complete.”

The following conditions will cause the RIC to terminate the EMU File Transfer Request of “EMU to GS” ID at any time prior to sending the Current Block Number equal to the Total Block Number:

Upon an error occurring in retrieving data from the EMU or the RIC receives an EMU File Transfer Request message with an ID “EMU to GS” and a Transfer Request Type of “File Transfer Stop”:

A. The RIC will send a “EMU to GS File Transfer Terminated” Rack Request Response to the EXPRESS laptop and Ground Stations, via telemetry.

    (1) And, if a payload originated the EMU File Transfer Request message transaction, the RIC will send back to that payload the same EMU File Transfer Request message except the RIC will set the EMU Request Type to “File Transfer Stop.”

B. The RIC will set the “EMU to GS File Transfer” status bit in the EXPRESS Rack Health and Status to “Not In Progress.”

At any time prior to sending the Current Block Number equal to the Total Block Number, if the RIC receives an EMU File Transfer Request message with an ID “EMU to GS” and a Transfer Request Type of “File Transfer Complete” the RIC will ignore the message.

The valid Directory names for an EMU File Transfer Request are shown in Table 11-XX.

The invalid responses will be sent to the requesting payload and, via telemetry, to the Ground Station and the EXPRESS laptop.

TABLE 11-XX EMU DIRECTORY ASSIGNMENTS

Directory Name	Directory Level	Directory Usage
(root directory)	0	None required by EMU file structure.
CFG	1	Location of all configuration files
PLD	1	Location of Payload File Transfer files
STM	1	Location of Stored Telemetry files
SWL	1	Location of Software Load files

The Rack Request Responses will be sent to the EXPRESS laptop and Ground Stations via telemetry and to the requesting payload.

The Response error codes are defined in Table 11-XXII.

11.2.3.5.6 Payload Response

The Payload Response shown in Table 11-XXI provides the payload or Payload Application with a RIC operating response to a RIC Service Request or message validation.

TABLE 11-XXI PAYLOAD RESPONSE FORMAT

MSB															LSB
SYNC (55AA)															
EXPRESS Header (Message Type = 0082h)															
Payload Response Code															

11.2.3.6 Payload Health and Status Data

The payload shall provide Health and Status (including Safety) data to the RIC at a rate of 1.0 Hz, continuously, while the payload is powered on. For any increment, the Health and Status data shall have a fixed length and fixed measurement location format in accordance with MSFC-STD-1274B, Volume 2, Section 4.4.3.2.5 (Random Sampling) and may be used by other payloads as ancillary data. Gaps in the Health and Status are on an exception basis and, for payloads using parameter monitoring as the primary means of fire detection, are subject to review and approval by the Payload Safety Review Panel.

The maximum number of Health and Status words is 92 data words (including Emergency, Caution, and Warning (ECW) word) plus 4 words of EXPRESS Header (see Figure 11-5 and Table 11-XXIII). The sync word and RS-422 serial checksum word are not

TABLE 11-XXII REQUEST RESPONSE CODE (Sheet 1 of 4) (28)

Error Code		
Request Response	Error Code (integer)	Request Error Code Description
No Error	0	Possible response to Procedure Execution Start, Procedure Execution Stop, Procedure Execution Resume, Install Bundle, Halt Bundle or Remove Bundle.
Invalid Ancillary Data Set Requested	1	Possible response to Ancillary Data Start request
Undefined Ancillary Data Set Requested	2	Possible response to Ancillary Data Start request
Request Ancillary Data Set Already Being Provided	3	Possible response to Ancillary Data Start request
Request Ancillary Data Set Not Being Provided	4	Possible response to Ancillary Data Stop request
Invalid Cycle Flag	5	Possible response to Ancillary Data Start request
Invalid File ID	15	Possible response to payload File Read or File Write request
PEP Command Buffer Full	20	Possible response to any payload request
Queue Full	21	Possible response to any payload request
Invalid Payload Request	23	Possible response to any payload request
Invalid Payload Index	24	Possible response to any payload request or CCSDS command
Invalid Sequence ID	30	Possible response to Procedure Start, Procedure Stop, or Procedure Resume request
Invalid Bundle ID	31	Possible response to Install Bundle, Halt Bundle, or Remove Bundle request
Sequence ID Not Found	32	Possible response to Procedure Start, Procedure Stop, or Procedure Resume request
Bundle ID Not Found	33	Possible response to Install Bundle, Halt Bundle, or Remove Bundle request
Unauthorized Sequence Execution Request	34	Possible response to Procedure Start, Procedure Stop, or Procedure Resume request
Unauthorized Bundle Execution Request	35	Possible response to Install Bundle, Halt Bundle, or Remove Bundle request
Timeliner Cmd Queue Full	36	Possible response to Install Bundle, Halt Bundle, Remove Bundle, Procedure Start, Procedure Stop, or Procedure Resume request
Max Transactions in Progress	64	Possible response to a Start File Read or a Start File Write

TABLE 11-XXII REQUEST RESPONSE CODE (Sheet 2 of 4) (28)

Error Code		
Request Response	Error Code (integer)	Request Error Code Description
FMT Timeout	68	Possible response to a Start File Read or a Start File Write.
Unauthorized File Request	76	Possible response to a Start File Read or a Start File Write.
File Transfer Completed	79	Possible response to a Start File Read or a Start File Write.
Restart File Transfer	80	Possible response to a Start File Read or a Start File Write.
File Transfer Error	81	Possible response to a Start File Read or a Start File Write.
Invalid Express Header Version	-268	EXPRESS header version does not match current version
Invalid Express Header Byte Count	-269	Message byte count does not match message length or pre-defined length
Invalid Express Header Message Type	-270	Message type value does not match any defined RIC message type
Invalid Source Function Code	-271	Source Function Code Does not exist or is not allowed to send this Message Type
Source Function Code Not Active	-272	Source Function Code is not active
Invalid Destination Function Code	-273	Destination Function Code does not exist or Destination Function Code is not accessible.
Destination Function Code Not Active	-274	Destination Function Code is not active
Invalid Mode	-275	command incompatible with RIC operating mode
EMU File Access Error	-276	access to EMU lost due to memory or communication error or file not found
Invalid Ancillary Data Set	-280	data set requested is outside valid range and does not exist
Invalid Add Entry Request	-281	entry to be added already exists or rack equipment is not available for addition
Invalid Delete Entry Request	-282	entry to be deleted does not exist or is not a valid entry to delete
Invalid Modify Entry Request	-283	entry to be modified does not exist or is not a modifiable entry

TABLE 11-XXII REQUEST RESPONSE CODE (Sheet 3 of 4) (28)

Error Code		
Request Response	Error Code (integer)	Request Error Code Description
Invalid Checksum Word	-286	A command or response received from the PEP has an invalid Checksum Word.
PLD Is Activated	-287	PLD commanded to be modified is powered and/or has an activated communication interface
Invalid Discrete Request	-288	Discrete channel set command contains invalid value
Invalid Rack Location	-293	location has already been assigned to another Function Code or is out of legal range
Invalid PLD Application Function Code	-295	PA Function Code is not unique in this rack
Invalid Serial Baud Rate Selected	-297	invalid serial baud rate was selected
Invalid Request Identifier	-298	undefined request identifier was entered
Ancillary Data Table Full	-308	Maximum number of Ancillary Data entries exceeded (either >16 Function Code entries or > 10 ancillary data sets requested per Function Code)
Duplicate IP Address	-309	IP Address already exists in another entry
Duplicate Subset ID	-310	Subset ID already exists in another entry
Invalid Comm Port Type	-311	Comm Port Type selected is not a valid choice for that entry
Rack Table Full	-312	Attempt to add entry when the Rack Config Table is already full. A current entry must be removed to allow a new entry.
Invalid Function Code	-313	Function Code is out of valid range or is already assigned to another entry or Source Function Code does not match Ancillary Data Destination Function Code
Bogus Execution Path	-315	An internal RIC invalid call was made.
Invalid Health and Status Size	-316	An invalid size was entered for the Health and Status Size
Invalid TCP/IP Port Number	-317	TCP/IP Port number was out of valid range
Rack Telemetry Config Table Full	-332	An entry can not be added until a current entry is deleted, because the Rack Telemetry Config Table is full.
Rack Telemetry Config Checkpoint Failure	-334	An internal RIC failure has inhibited the update of the Telemetry Config Checkpoint file on the EMU.
Ancillary Config Checkpoint Failure	-336	An internal RIC failure has inhibited the update of the Ancillary Data Config Checkpoint file on the EMU.

TABLE 11-XXII REQUEST RESPONSE CODE (Sheet 4 of 4) (28)

Error Code		
Request Response	Error Code (integer)	Request Error Code Description
Invalid Entry Specified	-340	The entry to be modified is invalid.
EMU to GS File Transfer in Progress	-341	A Ground Station Transfer is already in progress when another transfer request is made.
EMU to GS File Transfer Terminated	-342	A Ground Station Transfer was terminated before it was complete.
Invalid Block Number	-343	A File transfer request contains an invalid block number to restart from.
Invalid Health and Status Size	-344	The PLD Health and Status message does not match the Rack Config Table configured size.
Payload Telemetry Config Table Full	-345	A invalid command to add PLD Telemetry Config entry to a full PLD Telemetry configuration table.
Function Code Not Configured	-353	A command was issued to interface with a PL Function Code that is not configured.
Invalid Channel Number	-363	Invalid channel number was entered
PLD to EMU File Transfer In Progress	-368	PLD to EMU File Transfer was requested while one is already is in progress
PLD to EMU File Transfer Terminated	-369	PLD to EMU File Transfer was terminated while in progress
EMU to PLD File Transfer In Progress	-370	EMU to PLD File Transfer was requested while one is in progress
EMU to PLD File Transfer Terminated	-371	EMU to PLD File Transfer was terminated while in progress

The first word of Health and Status data shall be reserved by all payloads as the ECW word. Payloads using parameter monitoring as the primary means of fire detection shall set the ECW word to indicate potential for fire. Payloads not using parameter monitoring shall zero fill the ECW word. The integer 1 (Advisory) will be located at the most right bit (last transmit bit) in the 16-bit word.

Payloads shall provide as the second word of Health and Status data an H&S Cycle Counter. The H&S Cycle Counter shall be an unsigned 16 bit integer in the range of zero to 65,535. The H&S Cycle Counter shall be set to zero for the first H&S packet that the payload transmits. The H&S Cycle Counter shall be incremented by a value of one for each H&S packet transmitted. Once a value of 65,535 is reached, the H&S Cycle Counter for the following packet shall be reset to a value of zero and then the payload will continue incrementing the H&S Cycle Counter as noted above. This H&S Cycle Counter will be used by payload operations personnel to determine whether H&S data being received is stale.

PAYLOAD HEALTH AND STATUS DATA

1 Word	1 Word	1 Word	92 Words
Payload Subset ID	Service Request ID	Service Request Data Word	Payload Data Words (first one is ECW)

RIC-TO-P/L MDM

1 Word	4 Words	92 Words, Maximum, Payload Data			
Sync Word (55AA)	EXPRESS Header	ECW	H&S Cycle Counter	Payload Message* Figure 11-5A	

PAYLOAD-TO-RIC Payload Data

* Payloads are not required to reserve the Payload Message area within the H&S Data

FIGURE 11-5 PAYLOAD HEALTH AND STATUS

Payloads that require advisory messages to be displayed on a PCS onboard the ISS or displayed by payload operations personnel on the ground shall include those messages in their H&S data as shown in Figure 11-5. Payloads that do not require advisory messages to be displayed on a PCS onboard the ISS or by payload operations personnel on the ground are not required to reserve the payload message area within the H&S Data.

Payload messages shall be formatted as shown in Figure 11-5A. The Message Counter shall be an 8-bit unsigned integer in the range of zero to 255. The Message Counter initially contains a value of zero. The Message Counter shall be incremented by a value of one with each message issued by the payload. Once a value of 255 is reached, the Message Counter for the next message shall be reset to a value of zero and then the payload will continue incrementing the Message Counter as noted above.

The message identifier shall be an 8-bit unsigned integer in the range of zero to 255. The value of the message identifier and the associated text to be displayed will be captured during the development of the payload C&DH Data Set.

The RIC receives payload Health and Status data and verifies the correct EXPRESS Header with message type as 009Bh. After the verification process the RIC removes the

TABLE 11-XXIII PAYLOAD HEALTH AND STATUS (148)

MSB															LSB
SYNC (55AA)															
EXPRESS Header (Ref. Table 11-IV) (Destination Function Code = 0001 h) (Message Type = 009B h)															
Data Word 1															
• • •															
Data Word n (n Maximum Size = 92 Data Words for a single PLD)															
EXPRESS serial checksum word (only applicable for TIA/EIA-422 messages between the RIC and payloads. Consists of the sum, with no carry, of all message bytes, including Sync Word, prior to the EXPRESS Serial Checksum word).															

sync word, EXPRESS Header, and serial checksum word (RS-422 payload only) and adds the Subset ID, Service Request Word, and Service Request Data for each payload. The RIC combines all active payload Health and Status data in the order in which it is received and EXPRESS Subsystem Health and Status data as one EXPRESS Rack Health and Status message sent to the PL MDM at 1-Hz rate. The Subset ID word is always needed and the spaces for the Service Request ID and Service Request data words are reserved (zero filled when no request is present from the payload). The PL MDM (PEP) will combine all ISPR payload Health and Status data, APS status, PEHG status, and PL MDM status (not including the Timeline status and Ancillary) as one Health and Status message that is sent to the Ground Station.

A PD on the ground wanting to view any measurement in the PEP Health and Status data stream requests that measurement as part of the payload Ground Support Equipment (GSE) packet. It is possible to define Health and Status data within the Ground Data Services Data Set to be sent to the payload ground equipment such that only that specific payload’s Health and Status is received. This is accomplished by definition, at the individual parameter level.

11.2.3.7 EXPRESS Payload Commanding

A payload command comes to the RIC on board from the PEP or the EXPRESS laptop. A PEP command can originate from the ground by uplink or from on board by timeline command. EXPRESS Laptop commands are initiated by the crew. For uplink commands, the S-Band requires a minimum of 24 words (48 bytes) including the CCSDS header, ISS reserved words, payload command data words, and CCSDS command checksum word. The payload command data words include the EXPRESS Header and the payload command data words, but not the sync word. Commands can be of variable length, but the variable field must be at the end of the packet. The EHS builds the CCSDS packet for

Message Counter	Message Identifier
Most Significant Byte	Least Significant Byte

FIGURE 11-5A PAYLOAD MESSAGE FORMAT

payloads. The payload shall zero fill to reach the S-band minimum size. The maximum number of command words is 64 per command set including CCSDS header and command checksum word. The RIC receives the PEP command, compares the actual received number of words with the CCSDS packet length in Word 3, and checks the CCSDS checksum word. The RIC uses the length in the CCSDS header for verifying the received command length and uses the "Message Byte Count" in the first word of the EXPRESS Header for verifying the actual number of payload command byte(s). After the verification process the RIC issues the payload command to the destination Function Code. The RIC removes the CCSDS header, fill words, and checksum. The contents of the command message received by the payload will be the sync word at the beginning of the packet, EXPRESS Header, and the payload command data words. For an RS-422 payload the RIC will add the serial checksum word at the end of the message before sending it out to the payload. The sync word added by the RIC is not part of the command message. The Message Type is not used by the RIC and can be used by the payload for its own purpose as long as the contents are between 0100 to FFFE.

There is no database in the EXPRESS laptop for storing payload commands. However, a payload application may store a command and then issue it to the RIC as a payload message. A payload command originating from a payload application resident on the EXPRESS Laptop will be treated as a regular message between the payload application and the payload. The source Function Code is the payload application and the destination Function Code is the payload.

The format of commands that leave the EHS at MSFC on their way to payloads is as shown in Figure 11-6.

11.2.4 Laptop CSCI Interfaces

The EXPRESS Rack laptop CSCI interfaces to the PEHB via ANSI/IEEE-STD-802.3 (TCP/IP protocol). Payload interfaces to the laptop CSCI are the same as the PEHB which are defined in this section and shall be complied with for payloads using this interface.

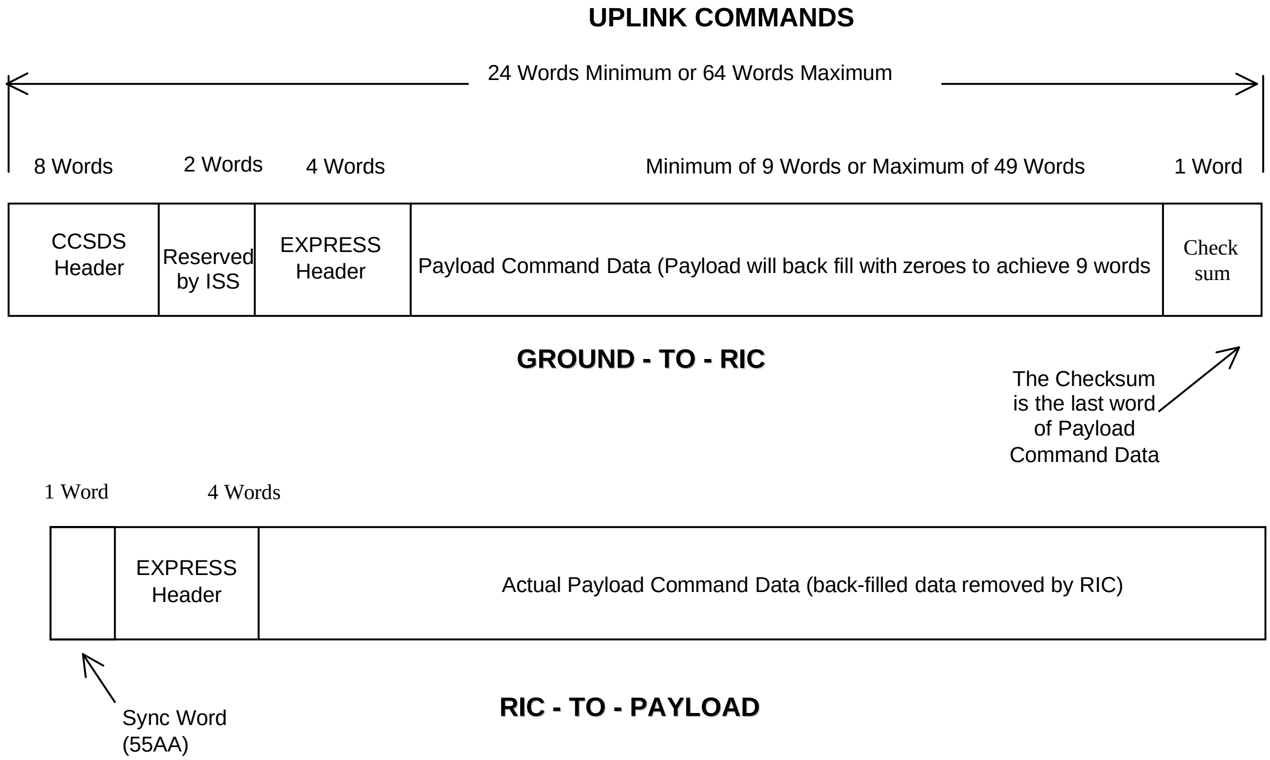


FIGURE 11-6 FORMAT OF PAYLOAD COMMANDS

The EXPRESS Rack laptop CSCI interfaces to a payload software application running on the laptop computer for exchange of payload commands and data shown in Table 11-XXIV. Commands destined for payloads are initiated by the payload software application. Data received from the RIC destined for the payload software application is routed to the payload software application.

TABLE 11-XXIV LAP CSCI EXTERNAL INTERFACE IDENTIFICATION (3-2)

NAME	DESCRIPTION	INTERFACE TYPE
LAP CSCI to PA	PLD data routed from the LAP CSCI to an experiment application running on the laptop computer	Software
PA to LAP CSCI	PLD requests initiated from the experiment application to be routed by the LAP CSCI	Software

The EXPRESS Rack laptop CSCI interfaces to the laptop computer hardware for obtaining user input events through the GUI, keyboard, or mouse and for sending data to the display screen.

The laptop CSCI interfaces with the UI application for the exchange of the user inputs and display data. The UI physical interface with the user includes the keyboard and GUI on the laptop display.

11.2.4.1 Laptop Data Elements

The laptop communication payload via the RIC CSCI through the PEHB using the Ethernet interface is defined as payload-to-payload communication and is shown in the Ethernet-related tables in this section.

11.2.4.2 Payload-Provided Software/Peripherals

All unique payload software and applications shall be payload provided. The payload may use standard 3.5 in floppy diskettes or CD-ROMs. It is recommended that the payload make arrangement to allow for testing the experiment hardware with the intended software installed in the EXPRESS Rack laptop.

11.2.4.3 EXPRESS Rack Laptop Display Requirements

EXPRESS Rack laptop computer payload displays are the responsibility of the PD. The displays shall conform to the requirements of SSP 50005, paragraph 9.4.2.3.2 and the style and display guide to be used are the U.S. Payload Operations Data File Management Plan, Annex 5: Payload Display Implementation Plan, SSP 58700-ANNX5, and Annex 6: Payload Display Developers Guide, SSP 58700-ANNX6.

11.2.4.4 Payload Software Interfaces

A. Laptop Communications

Communication between the payload and the payload-developed laptop application can be done directly if the payload communicates via Ethernet using a socket that is established between the two. Data packets sent between a payload application on the EXPRESS Laptop and the payload shall conform to Table 11-XXV. Payloads planning to use this approach must define in detail the quantity of data and frequency to be transmitted on the interface and enter this information in the payload-unique Command and Data Handling (C&DH) data set in the Payload Data Library (PDL). The availability of this interface is subject to operational constraints. The payload must know the laptop's Ethernet address and IP address and the payload-developed laptop application's TCP port. The Payload Software Integration and Verification

TABLE 11-XXV DATA PACKET REQUIREMENTS FOR DIRECT ETHERNET CONNECTIONS

ITEM	DESCRIPTION	COMMENTS/NOTES
1	Include the EXPRESS header per Table 11-IV as the first four words of the data portion of the packet.	1. The availability of this interface is subject to operational constraints. 2. The payload must know the EXPRESS laptop's Ethernet address/IP and the PD's laptop application's TCP port. 3. This direct communication link is not available to payloads that use the RS-422 link.
2	The rate of data transferred via the direct socket connection shall not exceed 100 kilobits per second.	1. The availability of this interface is subject to operational constraints. 2. The payload must know the EXPRESS laptop's Ethernet address/IP and the PD's laptop application's TCP port. 3. This direct communication link is not available to payloads that use the RS-422 link.

(PSIV) will integrate the laptop load, including the payload applications, and perform functional test and checkout to assure there are no load conflicts (including port number conflicts).

B. Software Updating Process for Laptop

EXPRESS laptop hard drive space available for all payloads in the rack is 750 Mbytes which is partitioned into ten 75-Mbyte partitions for individual payload use. The method of loading the payload application and data files on the EXPRESS laptop is done by loading all files on a compact disk for transport to the ISS at the beginning of the “increment.” This removable media would contain the new application and an install.exe or setup.exe which would install the application (as well as any data files needed by that application) into the correct predefined directory for that application. The compact disk may also contain file maintenance utilities by each payload that will purge the disk space of artifact files from the previous “increment” and will ensure that the payload files are loaded in the appropriate disk space.

The EXPRESS Payload Application load verification will be done at the PSIV facility. If the PD will send the verified software upgrade to the PSIV via CD, floppy disk, or FTP, the PSIV personnel will copy the payload software to the removable media for transport to the payload on board.

C. Payload Application to EXPRESS CSCI

The interface between EXPRESS LAP CSCI and a Payload Application is Named Pipe. Communication, as shown in Figure 11-7. The Payload Application receives the Payload Application message with correct Function Code from the LAP CSCI by Named Pipe (PIPEXXXX). The payload application sends the payload application message with correct Function Code to the LAP CSCI by SndRIC Pipe. The payload application message shall include the EXPRESS Header and first word of the EXPRESS telemetry secondary header, telemetry Data Type, and up to 1,248 bytes of data as shown in Table 11-XXVI.

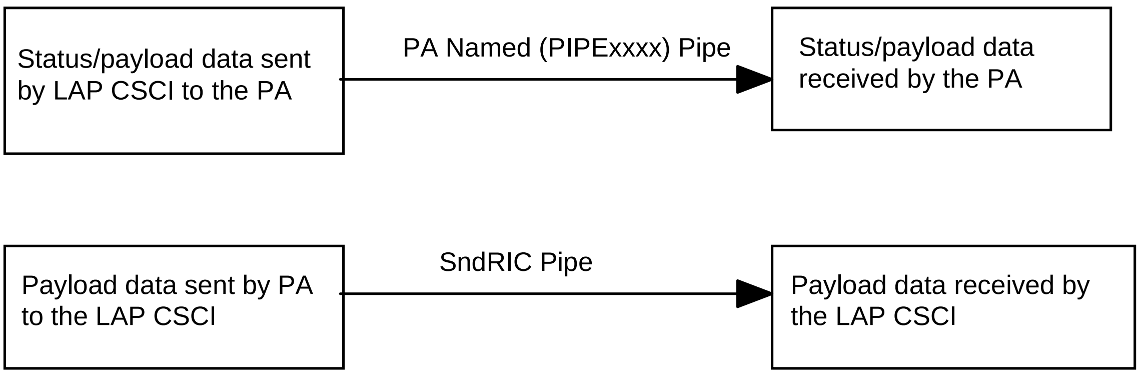


FIGURE 11-7 EXPRESS LAPTOP CSCI TO PAYLOAD APPLICATION DATA FLOW

TABLE 11-XXVI PA MESSAGE FORMAT

MSB	LSB
Header Version (4 bits)[1]	Message Byte Count (12 bits)[1 2]
Message Type[1]	
Function Code (Source)[1]	
Function Code (Destination) (0001 h or PA Function Code)[1]	
Telemetry Data Type (required for telemetry packets)	
Data Byte 1	Data Byte 2
Data Byte 3	Data Byte 4
. . .	
Data Byte n-1	Data Byte n (maximum n = 1248 Data Bytes)

[1] EXPRESS Header required for ALL communication to the LAP or RIC.
[2] Message Byte Count = Total Remaining Bytes in associated message

The Payload Application receives the message with the correct Function Code from the EXPRESS laptop by Named Pipe (PIPEXXXX). In C++ the name path on the laptop is \\\\.\\pipe\\PIPExxxx where xxxx is the Payload Application Function Code (assigned by EXPRESS EI). In the event the Payload Application Named Pipe is full, the laptop CSCI does not send data and will try sending three times before discarding the data. If data is received from a Payload Application that has not connected via Named Pipe, then that data is discarded immediately.

Payload messages sent from the Payload Application to the EXPRESS Laptop CSCI are by SndRIC or similar function. The Payload Application message shall include the EXPRESS Header, first word of EXPRESS telemetry secondary header (telemetry data type), and up to 1,248 bytes of data. In C++ the name path is \\\\.\\pipe\\SndRIC. The SndRIC Pipe is set to handle as many messages as there is physical room for on the system. The SndRIC is created in a way that disallows interruption of a WriteFile or ReadFile in progress. If an error occurs indicating the SndRIC Pipe is busy, the payload retries or quits.

The Payload Application can request RIC services and send telemetry data to the Ground Station by setting the destination Function Code to that of the RIC (0001h). The Payload Application request response format is the same as a payload response.

EXPRESS Rack subsystem Health and Status data is sent to the EXPRESS Laptop for display. Payload Health and Status data is not sent to the EXPRESS Laptop by the RIC. Payload Health and Status data to be processed or displayed by a Payload Application must be sent by each payload as a payload message to the Payload Application. The RIC will send all rack analog and discrete status data to all active Payload Applications connected via Named Pipe at a 1-Hz rate in the format shown in Table 11-XXVII.

11.2.4.5 File Maintenance

All payload-developed software applications shall include a file maintenance feature which will minimize hard disk space usage.

11.3 SOFTWARE SAFETY REQUIREMENTS FOR PAYLOADS

All software shall be considered 0-fault tolerant in the design of the payload hardware.

TABLE 11-XXVII RACK ANALOG AND DISCRETE DATA (Sheet 1 of 3)

MSB															LSB
Header Version (0 h) [1]				Message Byte Count (82 h) [1]											
Message Type (00B0 h) [1]															
Function Code (Source = 0001 h) [1]															
Function Code (Destination = PA Function Code) [1]															
SSPCM Discrete Status - 4 Words [2]															
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Z	Z	Z	FE	28	27	26	25	24	23	22	21	20	19	18	17
44	43	42	41	40	39	38	37	36	35	34	33	32	31	30	29
Z	Z	Z	FE	56	55	54	53	52	51	50	49	48	47	46	45
SSPCM A/D Input Status - 58 Words															
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 0											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 1											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 2											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 3											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 4											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 5											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 6											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 7											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 8											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 9											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 10											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 11											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 12											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 13											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 14											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 15											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 16											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 17											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 18											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 19											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 20											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 21											

TABLE 11- XXVII RACK ANALOG AND DISCRETE DATA (Sheet 2 of 3)

MSB															LSB
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 22											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 23											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 24											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 25											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 26											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 27											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 28											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 29											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 30											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 31											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 32											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 33											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 34											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 35											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 36											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 37											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 38											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 39											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 40											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 41											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 42											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 43											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 44											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 45											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 46											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 47											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 48											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 49											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 50											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 51											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 52											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 53											

TABLE 11- XXVII RACK ANALOG AND DISCRETE DATA (Sheet 3 of 3)

MSB															LSB
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 54											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 55											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 56											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 57											

[1] EXPRESS Header shown for clarity.

[2] SSPCM Discrete Status - 4 words:

FE = 15v AAA Fan Enable : --------------- 0 b = Reset, -------1 b = Set

Number = Bit I/O Discrete Number : ---- 0 b = Reset, -------1 b = Set

Z = always zero

SECTION 12, HUMAN FACTORS INTERFACE REQUIREMENTS

EXPRESS Rack PDs must be cognizant of various human factors requirements and considerations in the design of the payload. Human factors considerations can be categorized into safety requirements, equipment standardization and commonality considerations, and human interface considerations.

There are safety requirements which must be complied with and verified. These requirements are levied to protect the crew from exposure to hazardous conditions. The specific safety requirements are documented in the individual discipline sections of this document or in this section. Critical crew/human factors interfaces which must be complied with are also identified in this section.

12.1 PORTABLE ITEM HANDLES/GRASP AREAS/TEMPORARY STOWAGE RESTRAINTS

12.1.1 Provide Handles and Restraints

All removable or portable items that cannot be grasped with one hand as per Figure 12-1 shall be provided with handles or other suitable means of grasping, tethering, carrying, and restraining. Hand size dimensions are provided in Table 12-I. Figure 12-2 shows where the measurements are taken for hand size dimensions.

12.1.2 Handle Location

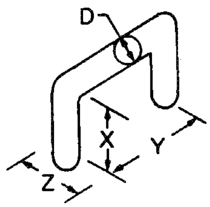
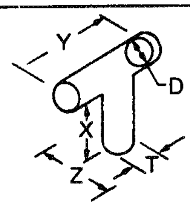
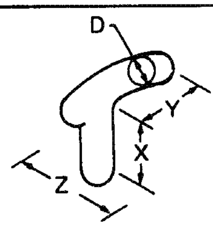
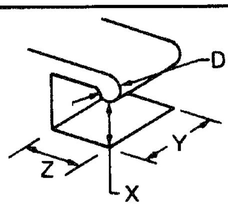
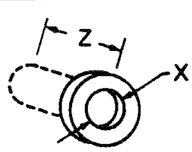
Handles and grasp area shall be placed on the accessible surface of an item consistent with the removal direction.

12.1.3 Handle Dimensions

IVA handles for movable or portable units shall be designed in accordance with the minimum applicable dimensions in Figure 12-1.

12.1.4 Handle Clearance

IVA clearances shall be provided between handles and obstructions consistent with dimensions given in Figure 12-1.

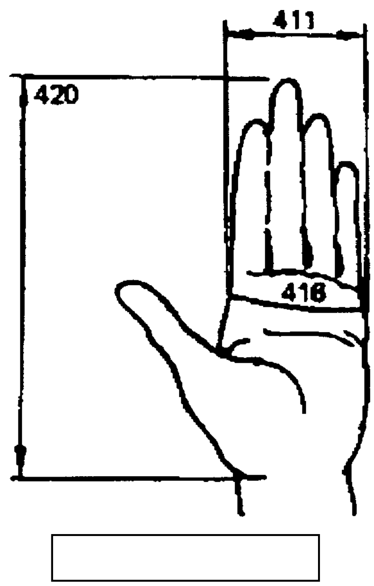
Illustration	Type of handle	Dimensions in mm (in inches) (Bare hand)		
		X	Y	Z
	Two-finger bar One-hand bar Two-hand bar	32 (1–1/4) 48 (1–7/8) 48 (1–7/8)	65 (2–1/2) 111 (4–3/8) 215 (8–1/2)	75 (3) 75 (3) 75 (3)
	T-bar	38 (1–1/2)	100 (4)	75 (3)
	J-bar	50 (2)	100 (4)	75 (3)
	Two-finger recess One-hand recess	32 (1–1/4) 50 (2)	65 (2–1/2) 110 (4–1/4)	75 (3) 90 (3–1/2)
	Finger-tip recess One-finger recess	19 (3/4) 32 (1–1/4)	– –	13 (1/2) 50 (2)

Curvature of handle or edge (DOES NOT PRECLUDE USE OF OVAL HANDLES)	Weight of Item	Minimum diameter	
	Up to 6.8 kg (up to 15 lbs)	D = 6 mm (1/4 in)	Gripping efficiency is best if finger can curl around handle or edge to any angle of 2/3 π rad (120°) or more
	6.8 to 9.0 kg (15 to 20 lbs)	D = 13 mm (1/2 in)	
	9.0 to 18 kg (20 to 40 lbs)	D = 19 mm (3/4 in)	
	Over 18 kg (over 40 lbs)	D = 25 mm (1 in)	
	T-bar post	T = 13 mm (1/2 in)	

FIGURE 12-1 HANDLE DIMENSIONS FOR IVA APPLICATIONS

TABLE 12-I HAND SIZE DIMENSIONS

	5th PERCENTILE FEMALE INCHES (MM)	95TH PERCENTILE MALE INCHES (MM)
Length (420)	6.2 (158)	8.1 (206)
Breadth (411)	2.7 (69)	3.8 (96)
Circumference (416)	6.5 (166)	9.2 (234)



Number	Measurement
420	Hand Length
411	Hand Breadth
416	Hand Circumference

FIGURE 12-2 HAND

12.1.5 Non-Fixed Handles Design Requirements

Hinged, foldout, or attachable (i.e., non-fixed) handles will comply with the following:

A. Nonfixed handles shall have a stop position for holding the handle perpendicular to the surface on which it is mounted.

B. Nonfixed handles shall be capable of being placed in the use position by one hand and shall be capable of being removed or stowed with one hand.

C. Attachable/removable handles shall incorporate tactile and/or visual indication of locked/unlocked status.

12.1.6 Tether Points

Tether points used on portable items for temporary stowage or placement purposes shall meet the structural margin of safety requirements specified in SSP 52005. These tether points shall be physically compatible with standard ISS tethers, or the PD shall provide the necessary tethers.

12.1.7 Captive Parts

Payloads and payload equipment shall be designed in such a manner to ensure that all unrestrained parts (e.g., attachment fasteners (payload-to-EXPRESS or payload-to-orbiter), locking pins, knobs, handles, lens covers, access plates, or similar devices) that may be temporarily removed on orbit will be tethered or otherwise held captive. Items not physically held captive shall provide a restraint capability such as tether, velcro, etc.

12.1.8 Temporary Stowage/Placement

All PD-provided stowage items shall have a method of securing them in place during on-orbit activities. Hook velcro patches shall be placed on all stowage items for the temporary stowage/placement purposes. These patches shall be no more than 4 in^2 in area. The size and shape should be consistent with the dimensions of the stowage item. Multiple velcro patches on a single stowage item are allowed.

Note: Use of velcro on the ISS is restricted to 4 in^2 and separated by a minimum of 2 in.

12.2 STRENGTH REQUIREMENTS

Forces and torques required to remove, replace, and operate, control, EXPRESS Rack payload hardware and equipment on orbit must be equal to or less than the strength values given below.

A. For operation and control of EXPRESS Rack payload hardware equipment:

(1) Grip Strength - To remove, replace, and operate EXPRESS Rack payload hardware, momentary and sustained grip strength required shall be less than the strength values for the 5^{th} percentile female defined as 50 percent of the strength values shown in Figure 12-3.

(2) Linear Forces - Linear forces required to operate or control EXPRESS Rack payload hardware shall be less than the strength values for the 5th percentile female, defined as 50 percent of the strength values shown in Figure 12-3 and 60 percent of the strength values shown in Figure 12-4.

(3) Torques - Forces/torques required to operate or control EXPRESS Rack payload hardware shall be less than the strength values for the 5th percentile female, defined as 60 percent of the calculated 5th percentile male capability shown in Figure 12-5.

B. Forces required for maintenance of EXPRESS Rack payload hardware shall be less than the 5th percentile male strength values shown in Figures 12-4, 12-5, 12-6, and 12-7.

12.3 BODY ENVELOPE AND REACH ACCESSIBILITY

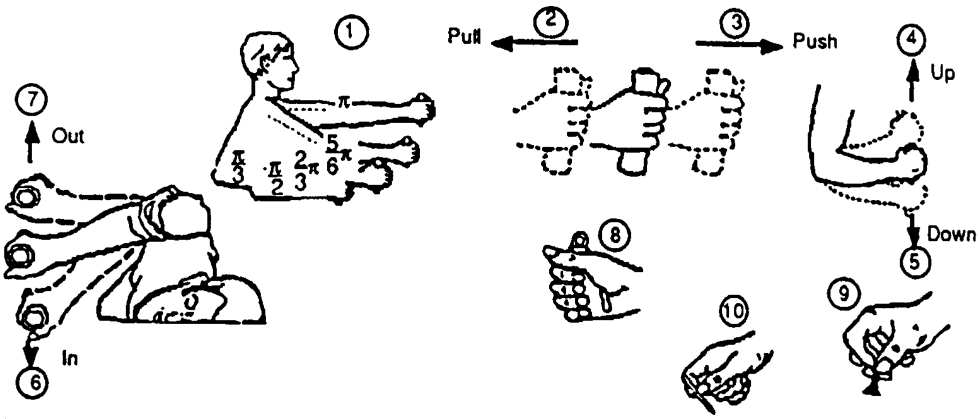
12.3.1 Operational Volume

The EXPRESS Rack payload shall provide volume, accessibility, and clearance for the crew to perform installation, operations, and maintenance tasks including clearance for hand access, tools, and equipment used in these tasks within the PD volume. Items which require use of volume outside of the individual PD volume should be identified to the rack integrator/ERO for consideration in an integrated assessment.

12.3.2 Accessibility

A. EXPRESS Rack payload hardware shall be geometrically arranged to provide physical and visual access for all installation, operations, and maintenance tasks. Payload ORUs should be removable along a straight path until they have cleared the surrounding structure.

B. IVA clearances for finger access shall be provided as given in Figure 12-8.



Arm strength (N)

(1)	(2)		(3)		(4)		(5)		(6)		(7)	
Degree of elbow flexion (rad)	Pull		Push		Up		Down		In		Out	
	L**	R**	L	R	L	R	L	R	L	R	L	R
π	222	231	187	222	40	62	58	76	58	89	36	62
5/6 π	187	249	133	187	67	80	80	89	67	89	36	67
2/3 π	151	187	116	160	76	107	93	116	89	98	45	67
1/2 π	142	165	98	160	76	89	93	116	71	80	45	71
1/3 π	116	107	96	151	67	89	80	89	76	89	53	76

Hand and thumb-finger strength (N)

	(8)		(9)	(10)
	Hand grip		Thumb-finger grip (Palmer)	Thumb-finger grip (tips)
	L	R		
Momentary hold	250	260	60	60
Sustained hold	145	155	35	35

* Elbow angle shown in radians
** L = Left; R = Right

Arm strength (lb)

(1)	(2)		(3)		(4)		(5)		(6)		(7)	
Degree of elbow flexion (deg)	Pull		Push		Up		Down		In		Out	
	L	R*	L	R	L	R	L	R	L	R	L	R
180	50	52	42	50	9	14	13	17	13	20	8	14
150	42	56	30	42	15	18	18	20	15	20	8	15
120	34	42	26	36	17	24	21	26	20	22	10	15
90	32	37	22	36	17	20	21	26	16	18	10	16
60	26	24	22	34	15	20	18	20	17	20	12	17

Hand, and thumb-finger strength (lb)

	(8)		(9)	(10)
	Hand grip		Thumb-finger grip (Palmer)	Thumb-finger grip (tips)
	L	R		
Momentary hold	56	59	13	13
Sustained hold	33	35	8	8

* Left; R = Right

FIGURE 12-3 ARM, HAND, AND THUM/FINGER STRENGTH
(5TH PERCENTILE MALE DATA)

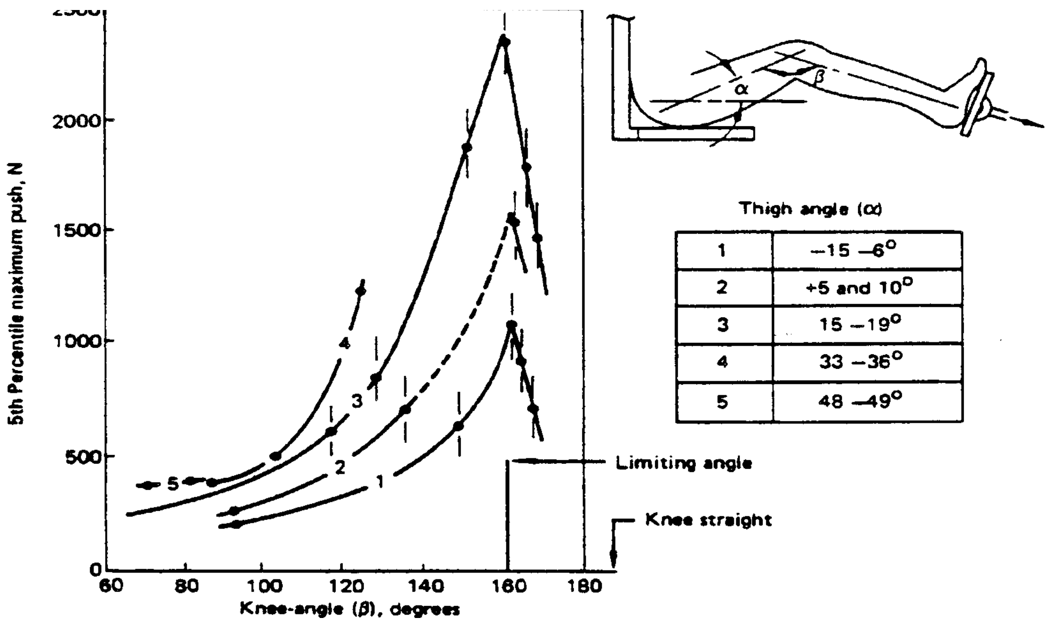


FIGURE 12-4 LEG STRENGTH AT VARIOUS KNEE AND THIGH ANGLES (5TH PERCENTILE MALE DATA)

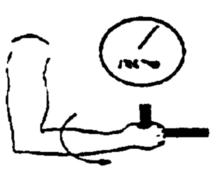
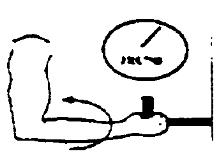
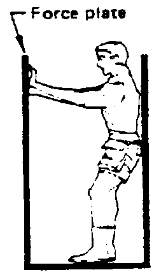
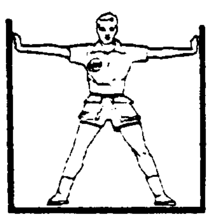
		Unpressurized suit, bare handed	
		Mean	SD
	Maximum torque: Suppination, Nm (lb-in.)	13.73 (121.5)	3.41 (30.1)
	Maximum torque: Pronation, Nm (lb-in.)	17.39 (153.9)	5.08 (45.0)

FIGURE 12-5 TORQUE STRENGTH

	Force-plate (1) height	Distances (2)	Force, N (lbf) Means	SD
			Both hands	
	100 percent of shoulder height	50	583 (131)	142 (32)
		60	667 (150)	160 (36)
		70	983 (221)	271 (61)
		80	1285 (289)	400 (90)
		90	979 (220)	302 (68)
		100	645 (145)	254 (57)
			Preferred hand	
		50	262 (59)	67 (15)
		60	298 (67)	71 (16)
		70	360 (81)	98 (22)
		80	520 (117)	142 (32)
		90	494 (111)	169 (38)
		100	427 (96)	173 (39)
		Percent of thumb-tip reach *		
	100 percent of shoulder height	50	369 (83)	138 (31)
		60	347 (78)	125 (28)
		70	520 (117)	165 (37)
		80	707 (159)	191 (32)
		90	325 (73)	133 (30)
		Percent of span **		

	Force-plate (1) height	Distances (2)	Force, N (lbf) Means	SD
	50	100	774 (174)	214 (48)
	50	120	778 (175)	165 (37)
	70	120	818 (184)	138 (31)
	Percent of shoulder height		1-g applicable data	

Notes:

(1) Height of the center of the force plate - 200 mm (8 in) high by 254 mm (10 in) long - upon which force is applied.

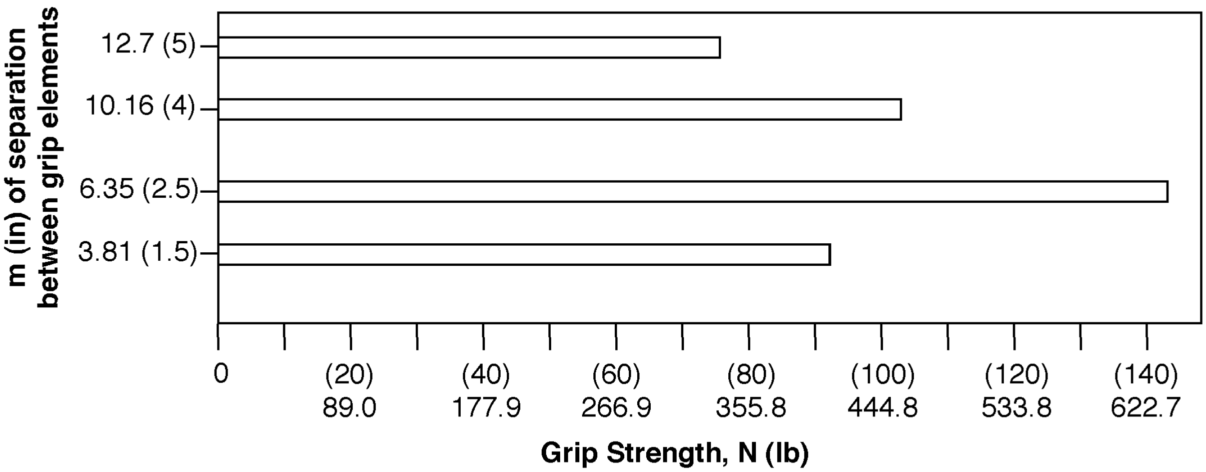
(2) Horizontal distance between the vertical surface of the force plate and the opposing vertical surface (wall or footrest, respectively) against which the subject brace themselves.

(*) Thumb-tip reach - distance from backrest to tip of subject's thumb as thumb and fingertips are pressed together.

(**) Span - the maximal distance between a person's fingertips as he extends his arms and hands to each side.

(3) 1-g data.

FIGURE 12-6 MAXIMAL STATIC PUSH FORCES



NOTE: 44 Subjects, all pilots or aviation cadets.

FIGURE 12-7 MALE GRIP STRENGTH AS A FUNCTION OF THE SEPARATION BETWEEN GRIP ELEMENTS

Minimal finger-access to first joint			
Push button access:	Bare hand: Thermal gloved hand	32mm dia. (1.26 in) 38 mm dia (1.5 in)	
Two finger twist access:	Bare hand: Thermal gloved hand	object plus 50mm (1.97 in) object plus 65 mm (2.56 in)	
FILE-FINGEROPS.CVS			

FIGURE 12-8 MINIMUM SIZES FOR ACCESS OPENING FOR FINGERS

12.3.3 Full Size Range Accommodation

All EXPRESS Rack payload work locations and hardware having crew nominal operations and planned maintenance shall be sized to meet the functional reach limits for the 5th percentile Japanese female and yet shall not constrict or confine the body envelope for the 95th percentile American male (reference SSP 50005, Section 3).

12.4 PAYLOAD HARDWARE MOUNTING

12.4.1 Equipment Mounting

Equipment items used during nominal operations and planned maintenance shall be designed, labeled, or marked to support proper installation.

12.4.2 Drawers and Hinged Panels

EXPRESS Rack payload ORUs or exchangeable items which are pulled out of their installed positions for routine checkout shall be mounted on equipment drawers or on hinged panels. Such drawers or hinged panels shall remain in the “open” position without being supported by hand.

12.4.3 Alignment

Payload hardware having blind mate connectors shall provide guide pins or their equivalent to assist in alignment of hardware during installation.

12.4.4 Slide-Out Stops

Limit stops shall be provided on slide or pivot-mounted subrack hardware which is required to be pulled out of its installed positions.

12.4.5 Push-Pull Force

Payload hardware mounted into a capture-type receptacle that requires a push-pull action shall require a force less than 35 lb (156 N) to install or remove.

12.4.6 Access

Access to inspect or replace a hardware item (e.g., an ORU or exchangeable item) which is planned to be accessed on a daily or weekly basis shall not require removal of another hardware item or more than one access cover.

12.4.6.1 Covers

Where physical access is required, one of the following practices must be followed, with the order of preference given.

A. A sliding or hinged cap or door shall be provided where debris, moisture, or other foreign materials might otherwise create a problem.

B. The cover plate shall be removable through the use of velcro, captive fasteners, or other self-containing method that does not preclude loose hardware during disassembly.

C. A quick-opening cover plate shall be provided if a cap will not meet stress requirements.

12.4.6.2 Self-Supporting Covers

All access covers that are not completely removable shall be self-supporting in the open position.

12.5 IDENTIFICATION LABELING

EXPRESS Rack payloads, loose equipment, stowage trays, consumables, ORUs, crew accessible connectors and cables, switches, indicators, and controls shall be labeled. Labels are markings of any form (including Inventory Management System (IMS) bar codes) such as decals and placards, which can be adhered, “silk screened,” engraved, or otherwise applied directly onto the hardware. Appendix E provides instructions for label and decal design and approval.

12.5.1 Color

Payloads shall select colors in accordance with the requirements of Table 12-II.

TABLE 12-II EXPRESS RACK PAYLOAD COLOR REQUIREMENTS

HARDWARE DESCRIPTION	COLOR	FINISH	COLOR NUMBER PER FED-STD-595B
Rack Front Aisle Extensions	Off-White	Semigloss	27722
Port, Starboard, Overhead, or Deck Rack Faceplates	Off-White	Semigloss	27722
Port, Starboard, Overhead, or Deck Rack Utility Panel Closeouts	Off-White	Semigloss	27722
Payload Faceplates	Off-White	Semigloss	27722
Stowage Trays	Off-White	Semigloss	27722
Stowage Tray Handle Straps (any location)	Blue Material	Semigloss	25102 or equivalent
Equipment Panel Text Characters	Black	Lusterless	37038

12.5.2 Fluid Connector Pressure/Flow Indicators

All non-brazed or non-welded gas and liquid lines that will be opened/disconnected on orbit shall be provided with a positive indication of the presence of gas pressure/fluid flow to verify that the line is passive before opening/disconnecting connectors (visual indicator, etc.). Any liquid or gas lines equipped with QDs which are designed to be operated under pressure shall not be required to be fitted with pressure/flow indicators.

12.5.3 Coding

A. Both halves of mating connectors shall display a code or identifier which is unique to that connection.

B. The labels or codes on connectors shall be located so they are visible when connected or disconnected.

12.5.4 Pin Identification

Pins shall be identified in each electrical plug and each electrical receptacle either by marking the pins or by an accompanying reference table. At least every 10th pin must be labeled.

12.6 CONTROLS AND DISPLAYS

12.6.1 Controls Spacing Design Requirements

All spacing between controls and adjacent obstructions shall meet the minimum requirements as shown in Figure 12-9, Control Spacing Requirements for Ungloved Operation.

12.6.2 Accidental Actuation

Requirements for reducing accidental actuation of controls are defined as follows:

12.6.2.1 Protective Methods

Payloads shall provide protection against accidental control actuation using one or more of the protective methods listed in sub-paragraphs A through G below. Infrequently used controls (i.e., those used for calibration) should be separated from frequently used controls. Lever-lock switches or switch covers are strongly recommended for switches related to mission success. Switch guards may not be sufficient to prevent accidental actuation.

A. Locate and orient the controls so that the operator is not likely to strike or move them accidentally in the normal sequence of control movements.

B. Recess, shield, or otherwise surround the controls by physical barriers. The control shall be entirely contained within the envelope described by the recess or barrier.

C. Cover or guard the controls. Safety or lock wire shall not be used.

D. Cover guards when open shall not cover or obscure the protected control or adjacent controls.

E. Provide the controls with interlocks so that extra movement (e.g., lifting switch out of a locked detent position) or the prior operation of a related or locking control is required.

F. Provide the controls with resistance (i.e., viscous or coulomb friction, spring-loading, or inertia) so that definite or sustained effort is required for actuation.

G. Provide the controls with a lock to prevent the control from passing through a position without delay when strict sequential actuation is necessary (i.e., the control moved only to the next position, then delayed).

Notes: (1) Switch covers or lever-lock switches are strongly recommended to prevent inadvertent actuation by crewmembers for all switches deemed by the PD to be critical for mission success. Switch guards are not sufficient to protect switches from accidental actuation. (2) Displays and controls used only for maintenance and adjustments which could disrupt normal operations if activated should be protected during normal operations, e.g., by being located separately or guarded/covered.

12.6.2.2 Noninterference

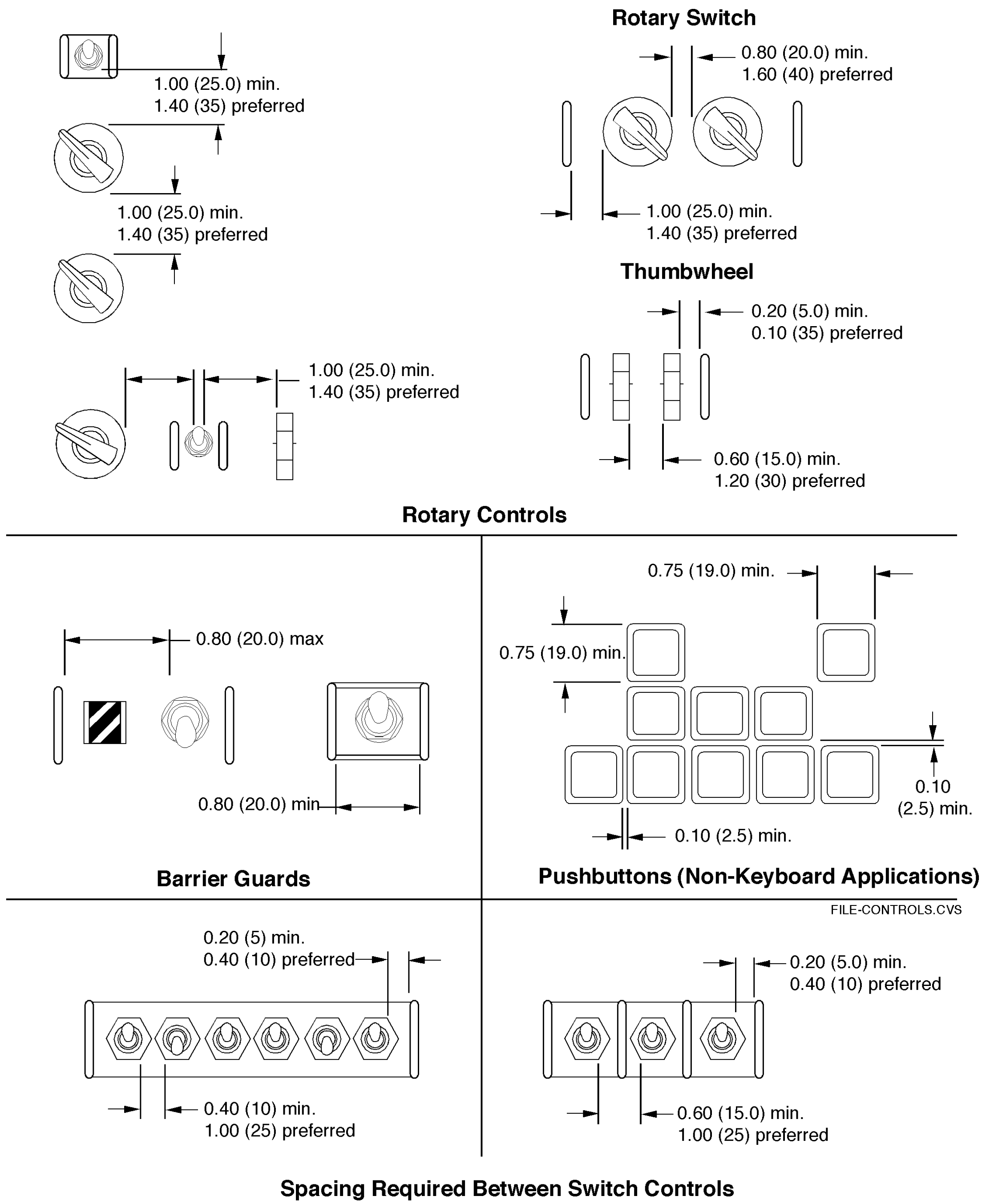
Payload-provided protection devices shall not cover or obscure other displays or controls.

12.6.2.3 Dead-Man Controls

Dead-man controls are covered under NSTS 1700.7, ISS Addendum, paragraphs 200.4a and 303.2.

12.6.2.4 Barrier Guards

Barrier guard spacing shall adhere to the requirements for use with the toggle switches, rotary switches, and thumbwheels as shown in Figures 12-9, Control Spacing Requirements for Ungloved Operation, and 12-10, Rotary Switch Guard.



NOTES:

1. All dimensions are in inches (mm).
2. Drawings not to scale.

FIGURE 12-9 CONTROL SPACING REQUIREMENTS FOR UNGLOVED OPERATION

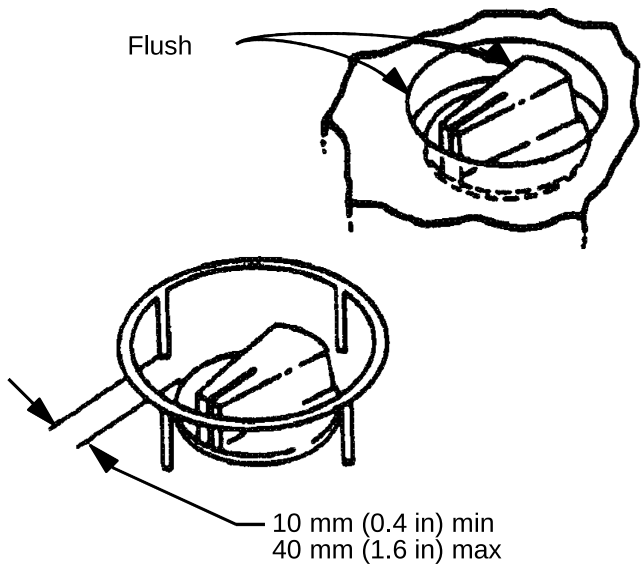


FIGURE 12-10 ROTARY SWITCH GUARD

12.6.2.5 Recessed Switch Protection

When a barrier guard is not used, rotary switches that control critical functions shall be recessed as shown in Figure 12-10, Rotary Switch Guard.

12.6.2.6 Position Indication

When payload switch protective covers are used, control position shall be evident without requiring cover removal.

12.6.2.7 Hidden Controls

Controls that cannot be directly viewed shall be avoided. If present, hidden controls shall be guarded to protect against inadvertent actuation.

12.6.2.8 Hand Controllers

Hand controllers (excluding trackballs and mice) shall have a separate on/off control to prevent inadvertent actuation when the controller is not in use.

12.6.3 Valve Controls

Requirements for design of payload valve controls are defined as follows:

A. Low-Torque Valves - Valves requiring 10 in-lb (1 N-m) or less for operation are classified as “low torque” valves and shall be provided with a “central pivot” type handle, 2.25 in (5.5 cm) or less in diameter (refer to Figure 12-12).

B. Intermediate-Torque Valves - Valves requiring between 10 and 20 in-lb (1 and 2 N-m) for operation are classified as “intermediate torque” valves and shall be provided with a “central pivot” type handle, 2.25 in (5.5 cm) or greater in diameter, or a “lever end pivot-type” handle, 3 in (7.5 cm) or greater in length.

C. High-Torque Valves - Valves requiring 20 in-lb (2 N-m) or more for operation are classified as “high-torque” valves and shall be provided “lever type” handles 3 in (7.5 cm) or greater in length.

D. Handle Dimensions - Valve handles shall adhere to the clearances and dimensions illustrated in Figures 12-11, Valve Handle-Central Pivot Type and 12-12, Valve Handle-Lever Type.

E. Rotary Valve Controls - Rotary valve controls shall open the valve with a counter-clockwise motion.

12.6.4 Toggle Switches

Dimensions for a standard toggle switch shall conform to the values presented in Figure 12-13, Toggle Switches.

12.6.5 Stowage and Equipment Drawers/Trays

A. All latches, handles, and operating mechanisms shall be designed to be latched/unlatched and opened/closed with one hand by the 95th percentile American male to the 5th percentile female.

B. The design of latches shall be such that their status (locked/unlocked) can be determined through visual inspection.

12.6.6 Audio Devices (Displays)

A. The design of audio devices (displays) and circuits shall protect against false alarms.

B. All audio devices (displays) shall be equipped with circuit test devices or other means of operability testing.

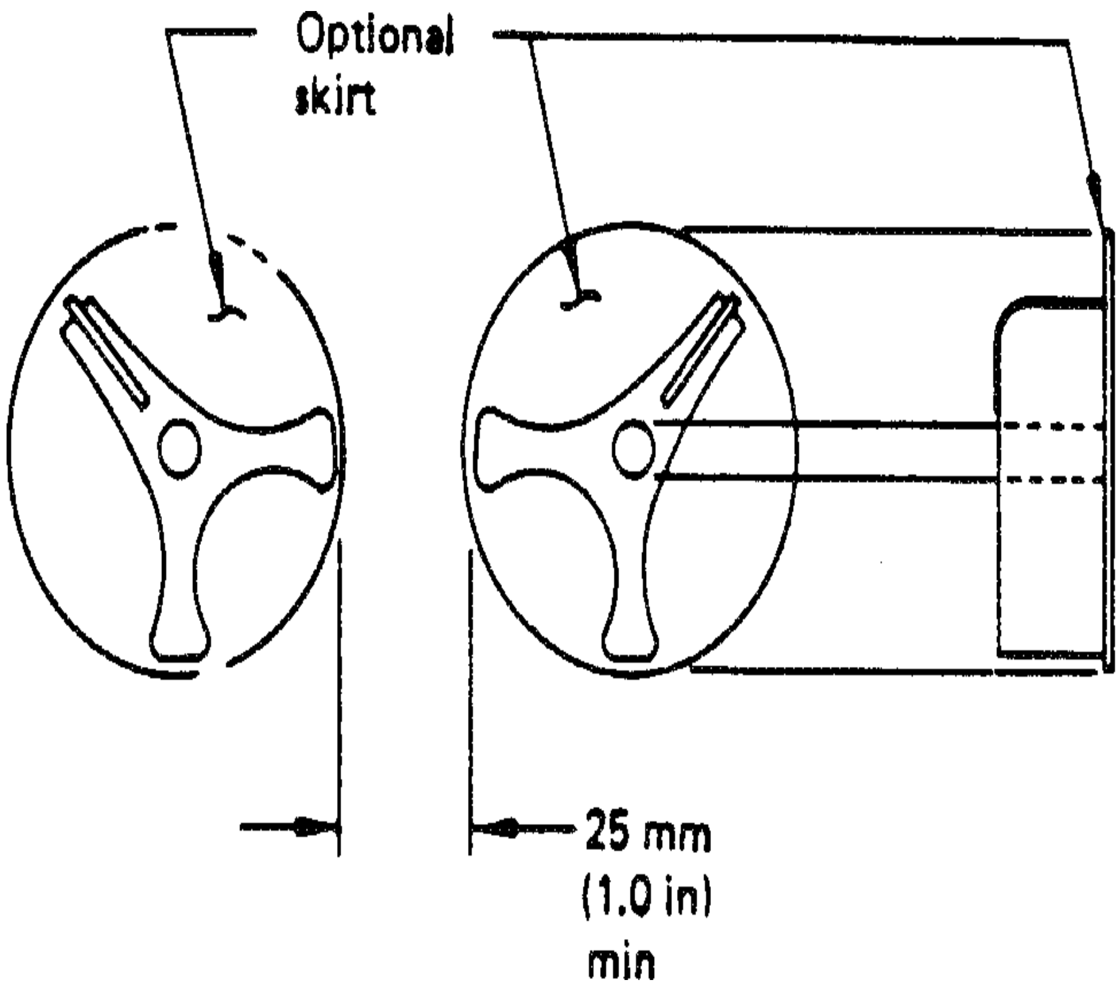


FIGURE 12-11 VALVE HANDLE - CENTRAL PIVOT TYPE

C. An interlocked, manual disable shall be provided if there is any failure mode which can result in a sustained activation of an audio device (display).

12.7 ELECTRICAL CONNECTOR DESIGN - GENERAL

All types of IVA connectors must meet the one-handed operation and accessibility requirements.

12.7.1 Mismatched

The design of electrical connectors shall make it physically incompatible to inadvertently reverse a connection or mate the wrong connectors if a hazardous condition can

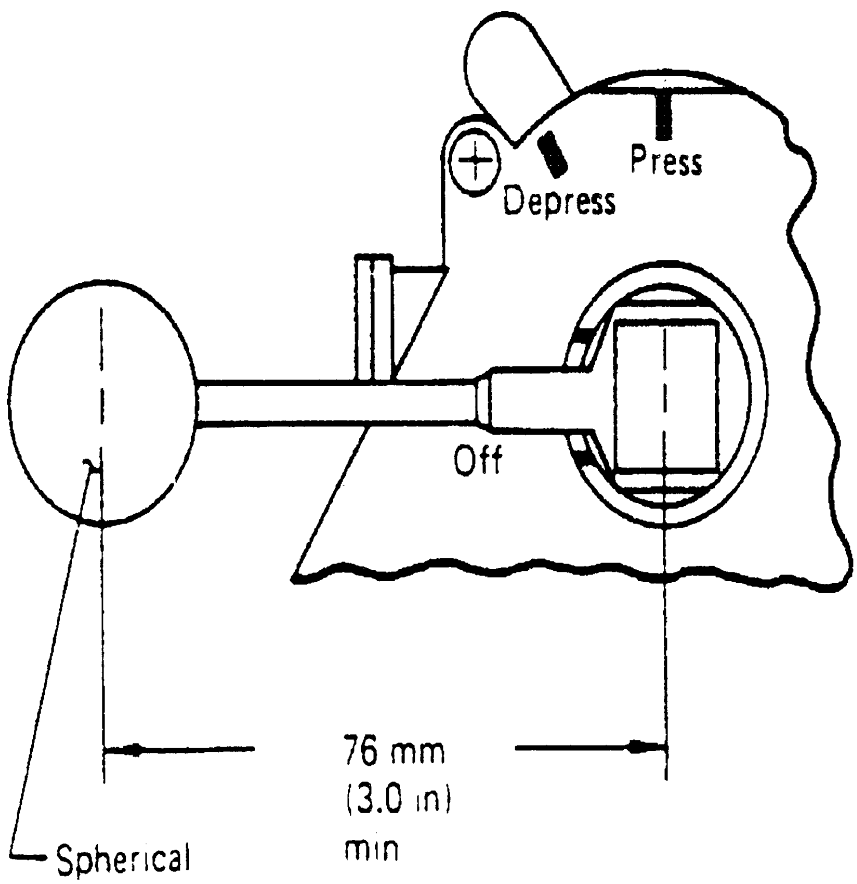


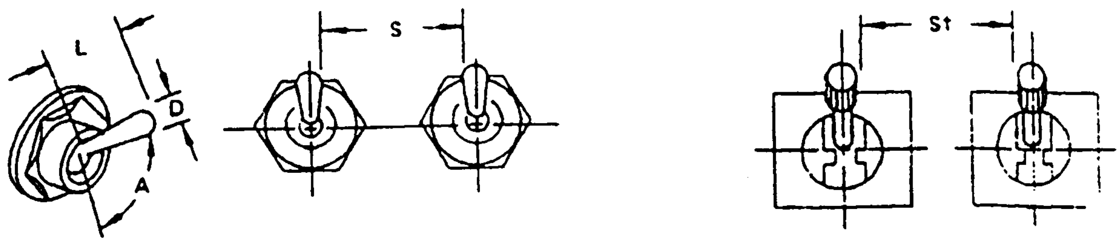
FIGURE 12-12 VALVE HANDLE - LEVER TYPE

be created. Payload and on-orbit support equipment, wire harnesses, and connectors shall be designed such that no blind connections or disconnections must be made during payload installation, operation, removal, or maintenance on orbit unless the design includes scoop proof connectors or other protective features (NSTS 1700.7 Addendum, paragraph 221).

Note: The use of identification (labeling) alone is not sufficient to mitigate mismating.

12.7.2 Connector Protection

Protection shall be provided for all demated connectors against physical damage and contamination.



	Dimensions		Resistance	
	L Arm length	D Control tip	Small switch	Large switch
Minimum	13 mm (1/2 in)	3mm (1/8 in)	2.8 N (10 oz)	2.8 N (10 oz)
Maximum	50 mm (2 in)	25 mm (1 in)	4.5 N (16 oz)	11 N (40 oz)

	Displacement between positions A	
	2 position	3 position
Minimum	30°	17°
Maximum	80°	40°
Desired		25°

	Separation S			
	Single finger operation	†	Single finger sequential operation	Simultaneous operation by different fingers
Minimum	19 mm (3/4 in)	25 mm (1 in)	13 mm (1/2 in)	16 mm (5/8 in)
Optimum	50 mm (2 in)	50 mm (2 in)	25 mm (1 in)	19 mm (3/4 in)

† Using a lever lock toggle switch

MSIS-239

Reference: 2, page 93

FIGURE 12-13 TOGGLE SWITCHES

12.7.3 Arc Containment

Electrical connector plugs shall be designed to confine/isolate the mate/demate electrical arcs or sparks.

12.7.4 Connector Arrangement

A. Space between connectors and adjacent obstructions shall be a minimum of 1 in (25 mm) for IVA access.

B. Connectors in a single row or staggered rows which are removed sequentially by the crew (IVA) shall provide 1 in (25 mm) of clearance from other connectors and/or adjacent obstructions for 270 degrees of sweep around each connector beginning at the start of its removal/replacement sequence.

12.7.5 One-Handed Operation

All connectors, whether operated by hand or tool, shall be designed and placed so they can be mated/demated using either hand.

12.7.6 Accessibility

A. Mate/Demate

(1) Nominal Operations - It shall be possible to mate/demate individual connectors without having to remove or mate/demate other connectors.

(2) Maintenance Operations - It shall be possible to mate/demate individual connectors without having to remove or mate/demate connectors on other ORUs or payloads.

B. Electrical connectors and cable installations shall permit disconnection and reconnection without damage to wiring connectors.

12.7.7 Ease of Disconnect

A. Electrical connectors which are mated/demated during nominal operations shall require no more than two turns to disconnect.

B. Electrical connectors which are mated/demated during ORU replacement operations only shall require no more than six turns to disconnect.

12.7.8 Self-Locking

Payload electrical connectors shall provide a self-locking feature.

12.7.9 Connector Shape

Subrack connectors shall use different connector shapes, sizes, or keying to prevent mating connectors when lines differ in content.

12.7.10 Fluid and Gas Line Connectors

Fluid and gas connectors that are mated and demated on-orbit shall be located and configured so that they can be fully inspected for leakage.

12.7.11 Fluid and Gas Line Connectors Mating

All fluid gas line connectors shall be configured so that it will be physically incompatible to prevent mismating. (Also see paragraph 12.7.1.)

12.7.12 Alignment Marks or Guide Pins

Mating parts shall have alignment marks in a visible location during mating or guide pins (or their equivalent).

Note: Keying a connector is considered equivalent to a guide pin.

12.7.13 Orientation

Grouped plugs and receptacles shall be oriented so that the aligning pins or equivalent devices are in the same relative position.

12.8 HOSE/CABLE RESTRAINTS

Hoses/cables shall be restrained as identified in Table 12-III.

TABLE 12-III HOSE/CABLE RESTRAINT REQUIREMENTS

ITEM	REQUIREMENT	REMARKS/NOTES
A	The loose ends of hoses and cables will be restrained.	
B	Conductors, bundles, or cables will be secured by means of clamps unless they are contained in wiring ducts or cable retractors.	
C	Cables of compatible classification will be bundled if multiple cables are running in the same direction. Class separation shall be maintained, where practical.	
D	Loose cables (longer than 1 ft (0.33 m)) must be restrained as follows: Length (m) — Restraint Pattern (% of length) tolerances +/- 10%) 0.33-1.00 — 50 1.00-2.00 — 33, 67 2.00-3.00 — 20, 40, 60, 80 >3.00 — at least each 0.5 m	

12.9 HABITABILITY/HOUSEKEEPING

12.9.1 Closures or Covers

Closures or covers shall be provided for any area of the payload that is not designed for routine cleaning.

12.9.2 Built-In Control

A. Payload containers of liquids or particulate matter shall have built-in equipment/methods for control of vaporization, material overflow, or spills.

B. The capture elements, including grids, screens, or filter surfaces shall be accessible for replacement or cleaning without dispersion of the trapped materials.

12.9.3 One-Handed Operation

Cleaning equipment and supplies shall be designed for one-handed operation or use.

12.10 WASTE MANAGEMENT

Deleted

12.11 MECHANICAL ENERGY DEVICES

Mechanical devices capable of storing energy (such as springs, spring-loaded levers, and torsion bars) shall be designed with safety features incorporated, such as locks, protective devices, and/or warning placards.

Design Guidance: Payload design should avoid mechanical devices capable of storing energy.

12.12 FASTENERS

12.12.1 Non-Threaded Fasteners

An indication of correct engagement (hooking, latch fastening, or proper positioning of interface parts) of non-threaded fasteners shall be provided.

12.12.2 Mounting Bolt/Fastener Spacing

Clearance around fasteners to permit fastener hand-threading (if necessary) shall be a minimum of 0.5 in for the entire circumference of the bolt head and a minimum of 1.5 in over 180 degrees of the bolt head and provide the tool handle sweep as seen in Figure 12-14. Excepted are NSTS standard MDLs or payload-provided hardware with the static envelope dimensions (cross-section) as specified in Figures 3-9, 3-10, and 3-12 and other similar captive fasteners arrangements.

12.12.3 Multiple Fasteners

When several fasteners are used on one item, they shall be of identical type.

12.12.4 Captive Fasteners

All fasteners planned to be installed and/or removed on orbit shall be captive when disengaged.

12.12.5 Quick Release Fasteners

A. Quick release fasteners shall require a maximum of one complete turn to operate (quarter-turn fasteners are preferred).

B. Quick release fasteners shall be positive locking in open and closed positions.

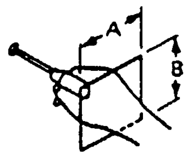
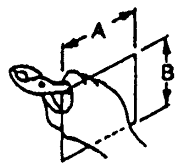
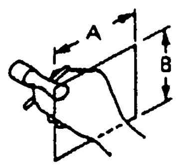
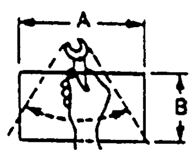
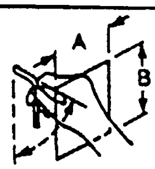
Opening dimensions		Task
	A 117 mm (4.6 in) B 107 mm (4.2 in)	Using common screw-driver with freedom to turn hand through 180 °
	A 133 mm (5.2 in) B 115 mm (4.5 in)	Using pliers and similar tools
	A 155 mm (6.1 in) B 135 mm (5.3 in)	Using T-handle wrench with freedom to turn wrench through 180°
	A 203 mm (8.0 in) B 135 mm (5.3 in)	Using open-end wrench with freedom to turn wrench through 62°
	A 122 mm (4.8 in) B 155 mm (6.1 in)	Using Allen-type wrench with freedom to turn wrench through 62°

FIGURE 12-14 MINIMAL CLEARANCE FOR TOOL-OPERATED FASTENERS

12.12.6 Threaded Fasteners

Only right-handed threads shall be used.

12.12.7 Over Center Latches

A. Nonself-latching - Over center latches shall include a provision to prevent undesired latch element realignment, interface, or reengagement.

B. Latch lock - Latch catches shall have locking features.

C. Latch handles - If the latch has a handle, the latch handle and latch release shall be operable by one hand.

12.12.8 Winghead Fasteners

Winghead fasteners shall fold down and be retained flush with surfaces.

12.12.9 Fastener Head Type

A. Hex-type external or internal grip or combination head fasteners shall be used where on-orbit crew actuation is planned, (e.g., ORU replacement).

B. If a smooth surface is required, flush or oval head internal hex grip fasteners shall be used for fastening.

Note: Phillips or torque-set fasteners may be used where fastener installation is permanent relative to planned on-orbit operations or maintenance, or where tool fastener interface failure can be corrected by replacement of the unit containing the affected fastener with a spare unit.

C. Slotted fasteners shall not be used to carry launch loads for hard-mounted equipment. Slotted fasteners are allowed in non-structural applications (e.g., computer data connectors, stowed commercial equipment).

12.12.10 One-Handed Actuation

Fasteners planned to be removed or installed on-orbit shall be designed and placed so they can be mated/demated using either hand.

12.12.11 Accessibility

Deleted

12.12.12 Access Holes

Covers or shields through which mounting fasteners must pass for attachment to the basic chassis of the unit shall have holes for passage of the fastener without precise alignment (and hand or necessary tool if either is required to replace).

12.13 PAYLOAD IN-FLIGHT OPERATIONS AND MAINTENANCE TOOLS

Payloads shall be designed to be operated and maintained using standard GFE tools defined at URL http://iss-www.jsc.nasa.gov/ss/issapt/opsipt/mresup/mresup_home.html or in SSP 50449.

SECTION 13, MATERIALS AND PARTS INTERFACE REQUIREMENTS

13.1 MATERIALS AND PROCESSES USE AND SELECTION

Materials and processes used in the design and construction of EXPRESS Rack payloads which directly or functionally interface with the ISS/carrier and the orbiter carrier shall comply with NSTS 1700.7, paragraphs 208.3 and 209 in their entirety, and NSTS 1700.7, ISS Addendum, paragraphs 208.3 and 209 in their entirety. Commercial/Off-The-Shelf (COTS) parts used in integrated racks shall meet these same materials requirements.

For those NASA centers which participate in the NASA Materials and Processes Intercenter Agreement for ISS payloads, the Intercenter Agreement baselines the process for selection and certification of materials used in payload hardware to the safety requirements of NSTS 1700.7 and NSTS 1700.7, ISS Addendum, paragraphs 208.3 and 209 in their entirety.

Whenever possible, materials should be selected that have already been shown to meet the applicable acceptance test criteria. Existing test data are compiled in the NASA Marshall Space Flight Center (MSFC) MAPTIS electronic database. A hardcopy version of the MAPTIS database is published periodically as a joint document with Johnson Space Center (JSC), MSFC-HDBK-527/JSC 09694, “Materials Selection List for Space Hardware Systems.”

13.1.1 Acceptance Criteria for Stress Corrosion Cracking (SCC)

Metallic materials (especially those considered to be structure members, such as payload structures, support bracketry, and mounting hardware, and those whose failure could result in a critical or catastrophic hazard) which have a high resistance (A-rated) to SCC according to the criteria of MSFC-SPEC-522 shall be used whenever possible.

13.1.2 Hazardous Materials and Compatibility

The use of materials, chemicals, and fluids which could create a toxic or hazardous situation for the crew, or which could contribute to the deterioration of hardware in service, shall be given special consideration as to adequate containment and compatibility.

13.1.3 Test and Acceptance Criteria for Flammability

Payload materials shall be nonflammable or self-extinguishing per the test criteria of NASA-STD-6001.

Note: Care is to be taken when integrating payloads, whether on the ground or in space, not to scratch the coated graphite composite surfaces of the EXPRESS Rack ISPR. Uncoated, the graphite material does not meet NASA flammability requirements.

13.1.4 Test and Acceptance Criteria for Toxic Offgassing (Toxicity)

All flight hardware located in habitable areas shall meet the toxicity offgassing acceptance requirements of NASA-STD-6001, Test 7.

13.2 GALVANIC CORROSION

Payloads using ISS aqueous fluid systems shall use internal materials that are compatible according to MSFC-SPEC-250, Table III, or that will not create a potential greater than 0.25 V with the ISS system internal materials due to a dissimilar metal couple.

13.3 FUNGUS-RESISTANT MATERIALS

Payloads that are intended to remain on-orbit for more than 1 year shall use fungus-resistant materials according to the requirements specified in SSP 30233, paragraph 4.2.10.

13.4 MATERIALS AND PARTS CERTIFICATION AND TRACEABILITY

For fracture-critical parts, traceability documentation per NASA-STD-5003 shall be located at the PD site and shall be collected and available for review upon request.

SECTION 14, FIRE PROTECTION

EXPRESS Rack payloads must not constitute an uncontrolled fire hazard to the ISS, EXPRESS Rack facility, or other payloads. Payloads must analyze all aspects of payload hardware, interfaces, materials, and operations to determine the level of fire risk of the payload based on the following requirements. A fire event detection smoke sensor is an integral part of the EXPRESS Rack. However, for a payload to take advantage of this feature it must interface with the AAA cooling loop. Smoke sensor activation is the only detection method that will result in the annunciation of a Class I fire alarm (illumination of the FIRE lamp on the module Caution and Warning (C&W) panel after two consecutive “smoke detected” signals from the smoke sensor). Note: A fire event location is defined as any partitioned volume in a rack that contains a potential fire source. If a payload contains several such volumes (excluding sealed containers), each volume shall be treated as a separate fire event location. The maximum volume allowed for a single fire event location is 60 ft^3. Detection is defined as a method of determining that a fire event or potential fire event has occurred within a fire event location.

In addition to the smoke sensor, the EXPRESS Rack also provides a smoke sensor indicator (a red LED) on the front of the rack for crew visual identification of the location and a PFE access port on the rack lower connector panel.

14.1 FIRE EVENT PREVENTION REQUIREMENTS

Payloads shall meet the fire prevention requirements specified in NSTS 1700.7, ISS Addendum, paragraph 220.10, and the following requirements to minimize the risk of a fire event.

14.1.1 Flammability Requirements

The payload configuration shall meet the flammability requirements of NSTS 1700.7 and ISS Addendum, paragraph 209.2. (Also refer to the detailed requirements in Section 13.1.3 of this document.)

14.1.2 Oxygen

The following requirements are applicable to payloads that contain or use supplies of pure oxygen or other strong oxidizers as part of their payload design/operations:

A. Pressure vessels or lines internal to a payload that contains oxygen or other strong oxidizers shall be designed to prevent leakage that would cause oxidizer buildup that exceeds material certification limits. The payload design shall meet the hazardous materials and fluid systems requirements contained in NSTS 1700.7 and ISS Addendum, paragraphs 209.1 and 209.1a.

B. Oxidizer delivery systems that include components such as valves, regulators, etc., designed to meter pure oxygen into a payload volume or sub-volume (i.e., as makeup due to respiration of life science specimens) shall meet the fault tolerant requirements of paragraph 200.1, NSTS 1700.7, ISS Addendum. Systems which are under active software control (i.e., control of discharge/metering valves) shall comply with paragraph 201.1e(1) of NSTS 1700.7 and ISS Addendum and NSTS/ISS 18798, Letter MA2-97-083, “Computer Control of Payload Hazards.”

C. The payload organization shall provide an assessment based on current design and worst-case failure scenarios (including the effects of loss of power and release of oxygen outside of the payload) that demonstrate compliance with the above requirements.

Note: Some examples of “strong oxidizers” are fluorine, MMH, N_2O_4, nitrous oxide, and any other oxidizer that may be used in conjunction with or within an experiment payload.

14.1.3 Electrical Systems

Payload electrical power distribution systems must comply with the wire derating and overcurrent protection requirements of Sections 6.2.2 and 6.2.3.

14.1.4 Payload Use of Battery Backup Power

Payloads shall be prohibited from using battery power to maintain payload operations when any or all of the following conditions exist:

A. Power to the rack/RIC is not available.

B. Payload Health and Status data cannot be processed/received beyond the payload or rack envelope.

14.2 PAYLOAD DATA MONITORING

Payloads that provide data parameter monitoring as their primary method of fire detection shall provide the capability for this data to interface with onboard crew and downlink data streams (e.g., ISS PCS). If a payload meets the requirements of a sealed container per NSTS 1700.7, no payload data parameter monitoring is required.

The EXPRESS payload parameter monitoring system for fire detection utilizes the PL MDM limit-checking services in combination with individual payload internal parameter monitoring to achieve the required functionality. EXPRESS payload data monitoring provides, as a minimum, the following: (1) The means for crew notification via computer display and via the ISS C&W (class 2); (2) the means for payload location via computer display; (3) automatic (safe) powerdown of the payload when crew notification of out-of-limit conditions exist. Note: It must not be possible to automatically reapply power.

A. All PD hardware when powered on shall output Health and Status data at 1 Hz continuously per Section 11. The content of the payload Health and Status/Safety data shall include payload subset ID (provided by ERO), payload service request, payload ECW word, and other PD Health and Status sensor information.

B. The payload shall be capable of monitoring key operating parameters (e.g., voltage, pressure, temperature, current, fan speed, etc.) and generating an ECW word as the first word of its Health and Status data that is sent to the EXPRESS Rack RIC. The exact set of data parameters to be monitored shall be negotiated jointly between the ISS program and the PD during the phased safety review process. The set of parameters shall be sufficient to characterize the fire potential while also reducing the possibility of false alarms. Preferably, data monitoring shall consist of multiple sensors of more than one type (i.e., two temperature sensors and two current monitors). Out-of-limit conditions which would constitute a potential fire or pyrolysis event would be defined as follows: When two or more sensors, of any type (predefined to provide a possible indication of fire or pyrolysis such as current, voltage, temperature, etc.) read out-of-limits simultaneously or within a relatively short time of each other.

C. The payload shall provide a logical combination of the monitored parameters and produce the ECW word 16-bit integer value as defined below:

   (1) 0 - No Problem

   (2) 1 - Advisory - System-initiated messages advising of a process status or other discrete event. Examples: Rendezvous solution complete, mass memory search for format in progress. Crew programmed reminder alerts keyed to time, orbit phase, bi-level state, parameter limit.

   (3) 3 - Warning - Conditions that require immediate correction to avoid loss or major impact to mission or potential loss of crew. Included are faults, failures, and out-of-tolerance conditions for functions critical to mission success.

14.2.1 Fire Event Location Indicator

A. Payloads that interface with the rack AAA and smoke sensor do not require a visual indicator light.

B. Payloads relying on data monitoring, without interfacing to the rack smoke detector, will not require a separate visual indicator unless it is deemed necessary by the PSRP.

14.3 PFE ACCESS PORT REQUIREMENTS

The following requirements are applicable to powered payload equipment:

A. Payload equipment in a sealed container (per NSTS 1700.7) or has an inert atmosphere inside does not require a PFE port.

B. Payload equipment that interfaces with the EXPRESS Rack AAA cooling system does not require a PFE port.

C. Powered payload equipment which is active in the orbiter middeck shall have a PFE access port.

D. Payload equipment that does not interface with the EXPRESS Rack AAA cooling system and has internal to the payload forced convection (i.e., cooling fan) shall have a PFE access port. This does not apply to payloads defined as sealed containers.

E. Payloads that do require a unique/dedicated PFE access port shall label the port to clearly distinguish it from the EXPRESS Rack PFE access port.

F. Aisle mounted subrack payload equipment having a forced air flow and a potential fire source shall have a PFE access port.

G. Subrack payload volumes, payloads or aisle-mounted equipment requiring a PFE access port having a panel thickness less than or equal to 0.125 inch (3.175 mm) shall provide a PFE access port 0.5 inch (12.7 mm) or 1.0 inch (25.4 mm) in diameter.

H. Subrack payload volumes, payloads or aisle-mounted equipment requiring a PFE access port having a panel thickness greater than 0.125 inch (3.175 mm) shall provide a PFE access port 1.0 inch (25.4 mm) in diameter.

Note: The ISS PFE has an open cabin diffuser nozzle which will be used to surround fire events with fire suppressant for aisle mounted equipment that does not exchange air with the cabin.

14.3.1 PFE Characteristics

The PFE CO_2 injection characteristics with which the payload shall be compatible are defined in SSP 30262:010, PFE Standard Interface Definition Document. The largest volume that can be extinguished by one PFE is 60 ft^3 (a single fire event location, equivalent to a single ISPR). Note: Payloads are responsible to assess their payload volume(s) for potential hazards (i.e., loss of structural integrity and/or release of toxic or harmful materials as a result of PFE (CO_2) discharge. Design solutions or controls must be identified and implemented if potential hazards have been identified. The ISS PFE will not be used in the Shuttle.

14.3.2 PFE Access Port Dimensions

The fire suppressant access port shall be a circular hole 0.5 in (1.27 cm) in diameter and shall be covered by a standard issue fire hole decal (P/N SDD32100397-003 or SDD32100397-004, Fire Hole Decal, per JSC 27260, Decal Process Document and Catalog). Note that the use of a 0.5 in diameter hole will allow the payload to maintain compatibility with both the PFE/ISS and the orbiter middeck fire extinguisher systems.

14.3.3 PFE Access

EXPRESS Rack payloads that plan to use an ISS PFE shall provide a keep-out envelope (including protrusions) sufficient to accommodate the PFE to the access port and shall be compatible with the PFE nozzle as shown in Figure 14-1.

14.3.4 PFE Quantity

Unless negotiated with ISS and agreed to by the PSRP, for each payload equipment item which requires a PFE access port, only one PFE access port shall be provided on the equipment item.

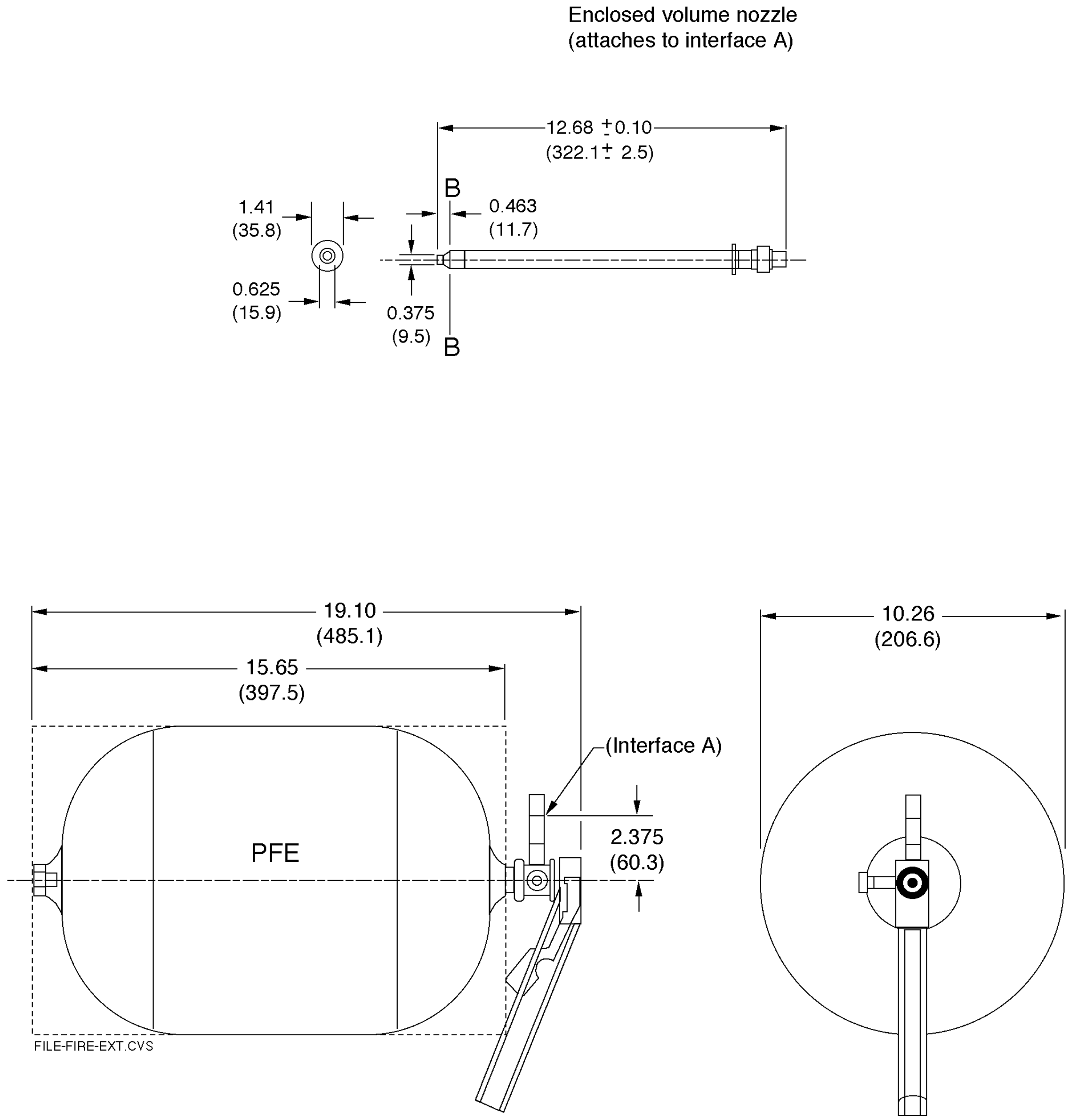
14.3.5 PFE Closeouts

For payload volumes (i.e., MDLs) that have PFE access ports to meet Space Shuttle pressurized cabin requirements but will not require a PFE port for ISS shall provide a blank closeout with the following characteristics: The PFE closeout completely covers the opening and shall be rigid and preclude access by a PFE; it shall not be labeled; and it shall possess, as close as possible, the same color as the background on which it resides. In addition, the closeout must be removable (with or without a tool is acceptable).

14.4 FIRE SUPPRESSANT DISTRIBUTION

Fire event locations shall be designed such that the oxygen concentration in the free volume of the location is reduced to 10.5 percent or less by volume within 1 min after the discharge of a single PFE or the fire event location is surrounded by the CO_2 within 1 min after the discharge of a single PFE.

Achieving oxygen reduction to the 10.5 percent level for payloads interfacing to the EXPRESS Rack AAA system after discharge of the PFE into the EXPRESS Rack PFE port



Notes:
1. All dimensions are in inches (mm).
2. Measurement from PFE centerline to point B with nozzle attached is approximately 14.59 inches (370.59 mm)

FIGURE 14-1 FIRE SUPPRESSANT PORT CLEARANCE will be verified by the rack integrator. EXPRESS Rack payloads which do not interface with the AAA cooling loop shall perform their own analysis using the criteria of this paragraph.

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APPENDIX A

ABBREVIATIONS AND ACRONYMS

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APPENDIX A, ABBREVIATIONS AND ACRONYMS

10BASE-T	Ethernet implementation
A	Amp, Ampere
A/m	Amperes per Meter
AAA	Avionics Air Assembly
ac	Alternating Current
ADL	Applicable Documents List
AF	Audio Frequency
AIT	Analysis and Integration Team
A/M	Amperes/Meter
ANC	Ancillary
ANSI	American National Standards Institute
APID	Application Process Identifier
APM	Attached Pressurized Module
APS	Automated Payload Switch
Ar	Argon
ARIS	Active Rack Isolation System
Async	Asynchronous
AT/PCI	Expansion Chassis Bus
AWG	American Wire Gauge
BSD	Berkeley Software Distribution
Btu	British Thermal Unit
C	Centigrade
°C	Degrees Celsius
C&DH	Command and Data Handling
C&W	Caution and Warning
CAM	Centrifuge Accommodation Module; Content Addressable Memory
cc	Cubic Centimeters
CCB	Configuration Control Board
CCSDS	Consultative Committee for Space Data Systems
cfm	Cubic Feet per Minute
CFU	Colony Forming Unit
CG	Center of Gravity
cm	Centimeter
CM	Crew Module
CMG	Control Moment Gyroscope
CO_2	Carbon Dioxide
COTS	Commercial Off-The-Shelf

CR	Change Request
CRES	Corrosion Resistant Steel
CSCI	Computer Software Configuration Item
CSMA/CD	Carrier Sense Multiple Access with Collision Detection
dB	Decibel(s)
dBA	Decibel, "A" weighted scale
dBm	Decibels Referenced to One Milliwatt
dBpT	Decibel, Picotesla
dc	Direct Current
DDPF	Decal Design and Production Facility
DEAP	Dryden Early Access Platform
DFRC	Dryden Flight Research Center
DQA	Data Quality Assurance
DR	Data Requirement
DRR	Document Release Record
DWG	Drawing
EAR	Export Administration Regulations
e.g.	exempli gratia (for example)
ECLSS	Environmental Control and Life Supporting System
ECW	Emergency, Caution, and Warning
EI	Engineering Integration
EIA	EXPRESS Integration Agreement
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EMU	EXPRESS Memory Unit
EPA	Environmental Protection Agency
ERO	EXPRESS Rack Office
ERP	EXPRESS Rack Payloads
ESD	Electrostatic Discharge
etc.	et cetera
EUT	Equipment Under Test
EXPRESS	EXpedite the PRocessing of Experiments to Space Station
F	Fahrenheit
°F	Degrees Fahrenheit
fc	Foot-Candle
ft	Foot, Feet
ft^3	Cubic Feet
FTP	File Transfer Protocol

g	Gravity
GB	Gigabit
GByte	Gigabyte
GFE	Government-Furnished Equipment
GHe	Gaseous Helium
GHz	Gigahertz
GN_2	Gaseous Nitrogen
g_{rms}	Gravity, Root Mean Square
GS	Ground Station
GSE	Government Support Equipment; Ground Support Equipment
GUI	Graphical User Interface
h	Hex
H_2O	Water
H&S	Health and Status
HDBK	Handbook
He	Helium
HOSC	Huntsville Operations Support Center
hr	Hour
HRDL	High Rate Data Link
Hz	Hertz
I-	Increment minus
IATC	Internal Active Thermal Control
ICA	Interface Control Annex
ICD	Interface Control Document
ID	Identifier
IDD	Interface Definition Document
i.e.	id est (that is)
I/F	Interface
I/O	Input/Output
IEEE	Institute of Electrical and Electronic Engineers
ILC	International Latex Corporation
IMS	Inventory Management System
in	Inch
in^2	Square Inch
in-lb	Inch-Pound
IPLAT	ISS Payload Label Approval Team
IRD	Interface Requirements Document
ISIS	International Subrack Interface Standard
ISO	International Standards Organization
ISPR	International Standard Payload Rack
ISS or ISSA	International Space Station or International Space Station Alpha

ISSP	International Space Station Program
ITCS	Internal Thermal Control System
IVA	Intravehicular Activity
I.V.	Intravenous
JEM	Japanese Experiment Module
JSC	Johnson Space Center
k	Kilo
KB	Kilobyte
kg	Kilogram
KHB	Kennedy Handbook
kHz	Kilohertz (kilocycles per second)
km	Kilometer
kPa	KiloPascal
KSC	Kennedy Space Center
kW	Kilowatt
L	Launch
L-	Launch minus
LAN	Local Area Network
LAP	Laptop
lb	Pound
lb/in	Pounds per Inch
lbf	Pound Force
lbm	Pound Mass
LCD	Liquid Crystal Display
LCP	Lower Connector Panel
LED	Light Emitting Diode
LISN	Line Impedance Simulation Network
LRDL	Low Rate Data Link
LRT	Low Rate Telemetry
LSB	Least Significant Bit
m	Meter
m^3	Cubic Meter(s)
mA	Milliampere
MAPTIS	Materials and Process Technology Information System
Max.	Maximum
MB	Megabit
Mbps	Megabytes per Second
MByte	Megabyte
MDK	Middeck

MDL	Middeck Locker
MDP	Maximum Design Pressure
MHz	Megahertz
MIL	Military
MIL-STD	Military Standard
min	Minute
Min.	Minimum
mm	Millimeter
mmHg	Millimeters of Mercury
mohm	Milliohm
MPG	Multiple Point Ground
MPLM	Multi-Purpose Logistics Module; Mini-Pressurized Logistics Module
MRDL	Medium Rate Data Link
ms	Millisecond
MSB	Most Significant Bit
MSFC	Marshall Space Flight Center
MTL	Moderate Temperature Loop
MUP	Middeck Utility Power
mV	Millivolt
N	Newton
N_2	Nitrogen
N/A	Not Applicable
NAR	Not a Requirement
nF	Nanofarad
N-m	Newton Meter
N/m^2	Newtons per Square Meter
NAS	National Aircraft Standard
NASA	National Aeronautics and Space Administration
NC	Noise Criteria
NHB	NASA Handbook
ns	Nanosecond
NSTS	National Space Transportation System
NTSC	National Television Standards Committee
O_2	Oxygen
oct	Octave
ODS	Orbiter Docking System
ORU	Orbital Replacement Unit
P/N	Part Number
PA	Payload Application
PAH	Payload Accommodations Handbook

PARD	Periodic and Random Deviation
PA/s	Pascal per Second
PCMCIA	Personal Computer Memory Card International Association
PCS	Portable Computer System
PD	Payload Developer
PDL	Payload Data Library
PDRP	Payload Display Review Panel
PEHB	Payload Ethernet Hub Bridge
PEHG	Payload Ethernet Hub Gateway
PEI	Payload Engineering Integration
PEP	Payload Executive Processor
PFE	Portable Fire Extinguisher
PFM	Pulse Frequency Modulated
PGSC	Payload and General Support Computer
PIM	Payload Integration Manager
PIRN	Preliminary/Proposed Interface Revision Notice
PL	Payload
PLD	Payload
PL MDM	Payload Multiplexer/Demultiplexer
PMP	Payload Mounting Panel
PODF	Payload Operations Data File
PPCB	Point-to-Point Communications Bus
ppm	Parts per Million
PRP	Pressurized Payloads
PRV	Pressure Relief Valve
psi	Pounds per Square Inch
psi/min	Pounds per Square Inch per Minute
psia	Pounds per Square Inch Absolute
psid	Pounds per Square Inch Differential
psig	Pounds per Square Inch Gauge
PSIV	Payload Software Integration and Verification
PSIV/F	PSIV Facility
PSRP	Payload Safety Review Panel
pT	Picotesla
PTC	Payload Training Center
PTR	Payload Technical Review
PU	Panel Unit
PVP	Payload Verification Plan
QD	Quick Disconnect
Qty.	Quantity

R+	Return plus
RAM	Random Access Memory
Ref	Reference
Rev.	Revision
RF	Radio Frequency
RI	Rockwell International
RIC	Rack Interface International
RMA	Rack Mobility Aid
ROM	Read Only Memory
Rx	Receiver
SAP	Single Adapter Plate
scc	Standard Cubic Centimeters
SCC	Stress Corrosion Cracking
sccs	Standard Cubic Centimeters per Second
scim	Standard Cubic Inches per Minute
SCS	Safety Critical Structure
sec	Second
SEE	Single Event Effect
SI	International System of Units
SLPM	Standard Liters per Minute
SMAC	Spacecraft Maximum Allowable Concentration
SPEC	Specification
SPG	Single Point Ground
SPL	Sound Pressure Level
SSP	Space Station Program
SSPC	Solid-State Power Controller
SSPCM	Solid-State Power Controller Module
SSTF	Space Station Training Facility
STD	Standard
STS	Space Transportation System
TACAN	Tactical Aircraft Navigation
TBC	To Be Confirmed
TBD	To Be Determined
TBE	Teledyne Brown Engineering
TCP/IP	Transmission Control Protocol/Internet Protocol
TM	Technical Memorandum
TW	Twisted
TWDS	Twisted Double Shielded
TWS	Twisted Shielded
Tx	Transmitter

UAD	Unique Ancillary Data
UF	Utilization Flight
UHF	Ultra High Frequency
UIL	User Interface Language
UP	Unpowered
U.S.	United States
USL	United States Laboratory
USOS	United States Orbital Segment
UTC	Universal Time Code
V	Volt
Vac	Volts, Alternating Current
Vdc	Volts, Direct Current
VES	Vacuum Exhaust System
V/m	Volts per Meter
Vol.	Volume
VPMP	Vented Payload Mounting Panel
Vrms	Volts, Root Mean Square
VRS	Vacuum Resource System
W	Watt
WCCS	Wireless Crew Communication System
WGS	Waste Gas System
Wt.	Weight
ΔP	Pressure Differential
µA	Microampere
µF	Microfarad
µg	Microgravity

APPENDIX B

TRACEABILITY MATRIX

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TABLE B-I TRACEABILITY MATRIX (Sheet 1 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
3	Physical and Mechanical Interfaces	N/A	N/A	Physical and Mechanical	Not a requirement.
3.1	Geometric Relationships	N/A	N/A	Physical and Mechanical	Not a requirement.
3.1.1	Crew Module (CM) Coordinate System	NSTS 21000-IDD-MDK, SSP 52005	3.1.1, 4.0	Physical and Mechanical	
3.1.2	International Standard Payload Rack (ISPR) Coordinate Systems (Limited Effectivity)	N/A	N/A	Physical and Mechanical	Not a requirement.
3.1.3	Payload (PL) Coordinate System	N/A	N/A	Physical and Mechanical	Not a requirement.
3.2	Dimensions and Tolerances	NSTS 21000-IDD-MDK	3.2	Physical and Mechanical	
3.3	Mechanical Interfaces	N/A	N/A	Physical and Mechanical	Not a requirement.
3.3.1	Middeck Locations	NSTS 21000-IDD-MDK	3.3	Physical and Mechanical	
3.3.1.1	Avionics Bay Locations	NSTS 21000-IDD-MDK	3.3.1	Physical and Mechanical	Not a requirement.
3.3.1.2	Middeck Payload Provisions	NSTS 21000-IDD-MDK	3.3.1	Physical and Mechanical	
3.3.2	ISS Locations	N/A	N/A	Physical and Mechanical	Not a requirement.
3.3.2A	ISS Locations	N/A	N/A	Physical and Mechanical	Not a requirement.
3.3.2B	ISS Locations	N/A	N/A	Physical and Mechanical	Not a requirement.
3.3.2C	ISS Locations	N/A	N/A	Physical and Mechanical	Not a requirement.
3.4	Mechanical Payload Provisions	N/A	N/A	Physical and Mechanical	Not a requirement.
3.4.1	EXPRESS Mounting Plates	N/A	N/A	Physical and Mechanical	Not a requirement.
3.4.1.1	8/2 EXPRESS Rack Mounting Plate	S683-34526	3.1.2.2.5(D)	Physical and Mechanical	
3.4.1.2	EXPRESS Transportation Rack Mounting Plate	Dwg 683-44394	N/A	Physical and Mechanical	
3.4.2	Standard Modular Locker	NSTS 21000-IDD-MDK	3.4.1	Physical and Mechanical	
3.4.2.1	Standard Stowage Trays	NSTS 21000-IDD-MDK	3.4.1.1	Physical and Mechanical	Not a requirement.
3.4.2.2	Modified Locker Access Door	NSTS 21000-IDD-MDK	3.4.1.2	Physical and Mechanical	
3.4.2.3	Payload Zero-G Requirements	NSTS 21000-IDD-MDK SSP 57000	3.4.1	Physical and Mechanical	Not a requirement.
3.4.2.3A	Payload Zero-G Requirements	NSTS 21000-IDD-MDK	3.4.1	Physical and Mechanical	
3.4.2.3B	Payload Zero-G Requirements	NSTS 21000-IDD-MDK	3.4.1	Physical and Mechanical	
3.4.2.3C	Payload Zero-G Requirements	NSTS 21000-IDD-MDK	3.4.1	Physical and Mechanical	

TABLE B-I TRACEABILITY MATRIX (Sheet 2 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
3.4.2.4	Isolation Material Properties	NSTS 21000-IDD-MDK	3.4.1	Physical and Mechanical	
3.4.2.5	ISS-Supplied Lockers	ISS Locker CDR Data Package	All	Physical and Mechanical	Design represented in the IDD. Rear closure panel still in work.
3.4.2.6	PD-Supplied Locker Requirements	NSTS-21000-IDD-MDK	Derived	Physical and Mechanical	
3.4.2.6A	PD-Supplied Locker Requirements	NSTS-21000-IDD-MDK	Derived	Physical and Mechanical	
3.4.2.6B	PD-Supplied Locker Requirements	N/A	N/A	Physical and Mechanical	Not a requirement.
3.4.3	Mounting Panels	NSTS 21000-IDD-MDK	3.4.2	Physical and Mechanical	
3.4.3.1	Single Adapter Plate	NSTS 21000-IDD-MDK	3.4.2.1	Physical and Mechanical	
3.4.3.2	Double Adapter Plate	NSTS 21000-IDD-MDK	3.4.2.2	Physical and Mechanical	
3.4.3.3	Payload Mounting Panel	NSTS 21000-IDD-MDK	3.4.2.3	Physical and Mechanical	
3.4.3.4	Vented Payload Mounting Panel	NSTS 21000-IDD-MDK	3.4.2.4	Physical and Mechanical	Preliminary based on pending IDD update.
3.4.3.4.1	Orbiter Inlet/Outlet Locations for Ducte Air-Cooled Payloads	NSTS 21000-IDD-MDK	3.8	Physical and Mechanical	
3.4.3.4.1.1	Orbiter Inlet/Outlet Locations for Singl Payload Accommodations	NSTS 21000-IDD-MDK	3.8.1	Physical and Mechanical	
3.4.3.4.1.2	Orbiter Inlet/Outlet Locations for Double Payload Accommodations	NSTS 21000-IDD-MDK	3.8.2	Physical and Mechanical	
3.4.3.5	Mounting Access	NSTS 21000-IDD-MDK	3.4.2.5	Physical and Mechanical	
3.4.3.5.1	On-Orbit Separation Interface Requirements	N/A	N/A	Physical and Mechanical	Not a requirement.
3.4.3.5.1A	On-Orbit Separation Interface Requirements	NSTS 21000-IDD-MDK	3.4.2.6	Physical and Mechanical	
3.4.3.5.1B	On-Orbit Separation Interface Requirements	NSTS 21000-IDD-MDK	3.4.2.6	Physical and Mechanical	

TABLE B-I TRACEABILITY MATRIX (Sheet 3 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
3.4.3.5.1C	On-Orbit Separation Interface Requirements	NSTS 21000-IDD-MDK	3.4.2.6	Physical and Mechanical	
3.4.3.5.2	Closeout Cover Access	NSTS 21000-IDD-MDK	3.4.2.6.2	Physical and Mechanical	Preliminary based on pending IDD update.
3.4.3.6	Payload Attachment Point Provisions	N/A	N/A	Physical and Mechanical	Not a requirement.
3.4.3.6.1	Orbiter/Middeck	NSTS 21000-IDD-MDK	3.4.2.4	Physical and Mechanical	
3.4.3.6.1.1	Attachment Hardware – Payloads Without Planned On-Orbit Transfers			Physical and Mechanical	
3.4.3.6.1.2	Attachment Hardware – Payloads with Planned On-Orbit Transfers			Physical and Mechanical	
3.4.3.6.2	EXPRESS Rack Backplate	S683-34526	3.1.2.2.5	Physical and Mechanical	
3.4.3.6.2.1	Interface Attachment Capabilities	D683-43600	**TBD**	Physical and Mechanical	Derived. **TBD** in this paragraph.
3.4.3.6.2.2	Maximum Dimensions Envelope	SSP 57000	3.1.1.4.J	Physical and Mechanical	Derived
3.4.3.6.3	Captive Fasteners	NSTS 21000-IDD-MDK, SSP 57000	3.4.2.5.1, 3.4.2.5.2, 3.12.4.4.5	Physical and Mechanical	
3.4.3.6.4	On-Orbit Removal of Fasteners	NSTS 21000-IDD-MDK, SSP 57000	3.4.2.5.1, 3.4.2.5.2, 3.12.9.9	Physical and Mechanical	
3.4.4	ISIS Drawer Payload Provisions	N/A	N/A	Physical and Mechanical	Not a requirement.
3.4.4.1	Stowage ISIS Drawers	N/A	N/A	Physical and Mechanical	Not a requirement.
3.4.4.1A	Stowage ISIS Drawers	S683-34526, ISIS-01	3.2.1.1, 3.1.1	Physical and Mechanical	
3.4.4.1B	Stowage ISIS Drawers	S683-34526, ISIS-01	3.2.1.1, 3.1.1	Physical and Mechanical	
3.4.4.1C	Stowage ISIS Drawers	S683-34526, ISIS-01	3.2.1.1, 3.1.1	Physical and Mechanical	
3.4.4.1D	Stowage ISIS Drawers	S683-34526, ISIS-01	3.2.1.1, 3.1.1	Physical and Mechanical	
3.4.4.1E	Stowage ISIS Drawers	S683-34526, ISIS-01	3.2.1.1, 3.1.1	Physical and Mechanical	
3.4.4.2	Powered ISIS Drawers	N/A	N/A	Physical and Mechanical	Not a requirement.
3.4.4.2A	Powered ISIS Drawers	S683-34526, ISIS-01	3.2.1.1, 3.1.1	Physical and Mechanical	
3.4.4.2B	Powered ISIS Drawers	S683-34526, ISIS-01	3.2.1.1, 3.1.1	Physical and Mechanical	
3.4.4.2C	Powered ISIS Drawers	S683-34526, ISIS-01	3.2.1.1, 3.1.1	Physical and Mechanical	
3.4.4.2D	Powered ISIS Drawers	S683-34526, ISIS-01	3.2.1.1, 3.1.1	Physical and Mechanical	
3.4.4.2E	Powered ISIS Drawers	S683-34526, ISIS-01	3.2.1.1, 3.1.1	Physical and Mechanical	
3.4.4.2F	Powered ISIS Drawers	S683-34526, ISIS-01	3.2.1.1, 3.1.1	Physical and Mechanical	

TABLE B-I TRACEABILITY MATRIX (Sheet 4 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
3.4.4.2G	Powered ISIS Drawers	S683-34526, ISIS-01	3.2.1.1, 3.1.1	Physical and Mechanical	
3.4.4.3	ISIS Drawer Replacement	N/A	N/A	Physical and Mechanical	Not a requirement.
3.4.5	Securing of Threaded Fasteners	SSP 52005	5.6	Physical and Mechanical	
3.4.5.1	Fracture-Critical Threaded Fasteners	SSP 52005	5.6	Physical and Mechanical	
3.4.5.2	Redundant Threaded Fasteners Locking Requirements	N/A	N/A	Physical and Mechanical	Not a requirement.
3.4.5.2A	Redundant Threaded Fasteners Locking Requirements	SSP 52005	5.6	Physical and Mechanical	
3.4.5.2B	Redundant Threaded Fasteners Locking Requirements	SSP 52005	5.6	Physical and Mechanical	
3.4.5.2C	Redundant Threaded Fasteners Locking Requirements	SSP 52005	5.6	Physical and Mechanical	
3.4.5.2D	Redundant Threaded Fasteners Locking Requirements	SSP 52005	5.6	Physical and Mechanical	
3.4.5.2E	Redundant Threaded Fasteners Locking Requirements	SSP 52005	5.6	Physical and Mechanical	
3.4.5.2F	Redundant Threaded Fasteners Locking Requirements	SSP 52005	5.6	Physical and Mechanical	
3.5	Ground Support Equipment (GSE)	NSTS 21000-IDD-MDK	3.5	Physical and Mechanical	Not a requirement.
3.5.1	Ground Handling	NSTS 21000-IDD-MDK	3.5	Physical and Mechanical	Not a requirement.
3.5.2	MPLM Late/Early Access Requirements	SSP 57000	3.1.1.2.1	Physical and Mechanical	
3.5.2.1	MPLM Late Access Envelope (Kennedy Space Flight Center (KSC))	SSP 57000	3.1.1.2.1.1	Physical and Mechanical	Not a requirement.
3.5.2.1A	MPLM Late Access Envelope (Kennedy Space Flight Center (KSC))	SSP 57000	3.1.1.2.1.1	Physical and Mechanical	
3.5.2.1B	MPLM Late Access Envelope (Kennedy Space Flight Center (KSC))	SSP 57000	3.1.1.2.1.1	Physical and Mechanical	
3.5.2.1C	MPLM Late Access Envelope (Kennedy Space Flight Center (KSC))	SSP 57000	3.1.1.2.1.1	Physical and Mechanical	
3.5.2.2	MPLM Early Access Envelopes (KSC an Dryden Flight Research Center (DFRC))	SSP 57000	3.1.1.2.1.2	Physical and Mechanical	Not a requirement.

TABLE B-I TRACEABILITY MATRIX (Sheet 5 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
3.5.2.2A	MPLM Early Access Envelopes (KSC and Dryden Flight Research Center (DFRC))	SSP 57000	3.1.1.2.1.2	Physical and Mechanical	
3.5.2.2B	MPLM Early Access Envelopes (KSC and Dryden Flight Research Center (DFRC))	SSP 57000	3.1.1.2.1.2	Physical and Mechanical	
3.6	Envelope Requirements	N/A	N/A	Physical and Mechanical	Not a requirement.
3.6.1	Payload Static Envelopes	N/A	N/A	Physical and Mechanical	Not a requirement.
3.6.1A	Payload Static Envelopes	S683-34526, ISIS-01	3.2.1.1	Physical and Mechanical	
3.6.1B	Payload Static Envelopes	S683-34526, NSTS 21000-IDD-MDK	3.1.2.2.5, 3.7	Physical and Mechanical	
3.6.1C	Payload Static Envelopes	S683-34526, NSTS 21000-IDD-MDK	3.1.2.2.5, 3.7	Physical and Mechanical	
3.6.2	On-Orbit Payload Protrusions	SSP 57000	3.1.1.7	Physical and Mechanical	Not a requirement.
3.6.2A	On-Orbit Payload Protrusions	SSP 57000	3.1.1.7	Physical and Mechanical	
3.6.2B	On-Orbit Payload Protrusions	SSP 57000	3.1.1.7	Physical and Mechanical	
3.6.2.1	Front Face Protrusions (Permanent)	SSP 57000	3.1.1.7.1	Physical and Mechanical	
3.6.2.2	On-Orbit Semi-Permanent Protrusions	SSP 57000	3.1.1.7.2	Physical and Mechanical	Not a requirement.
3.6.2.2A	On-Orbit Semi-Permanent Protrusions	SSP 57000	3.1.1.7.2	Physical and Mechanical	
3.6.2.2B	On-Orbit Semi-Permanent Protrusions	SSP 57000	3.1.1.7.2	Physical and Mechanical	
3.6.2.3	On-Orbit Temporary Protrusions	SSP 57000	3.1.1.7.3	Physical and Mechanical	Not a requirement
3.6.2.3A	On-Orbit Temporary Protrusions	SSP 57000	3.1.1.7.3A	Physical and Mechanical	
3.6.2.3B	On-Orbit Temporary Protrusions	SSP 57000	3.1.1.7.3B	Physical and Mechanical	
3.6.2.4	On-Orbit Momentary Protrusions	SSP 57000	3.1.1.7.4	Physical and Mechanical	
3.6.2.5	On-Orbit Protrusions for Keep-Alive Payloads	SSP 57000	3.1.1.7.5	Physical and Mechanical	
3.6.3	Sharp Edges and Corners	SSP 50005, Rev. B, SSP 52000 NSTS 1700.7B/ISS Addendum	6.3.3.1, 3.12.9.2, 222.1	Physical and Mechanical	

TABLE B-I TRACEABILITY MATRIX (Sheet 6 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
3.6.3.1	Protective Covers/Shield	SSP 50005, Rev. B, NSTS 1700.7B/ISS Addendum	6.3.3.3, 222.1	Physical and Mechanical	
3.6.3.2	Holes	SSP 50005, Rev. B, NSTS 1700.7B/ISS Addendum	6.3.3.4, 222.1	Physical and Mechanical	
3.6.3.3	Screws/Bolts Ends	SSP 50005, Rev. B, NSTS 1700.7B/ISS Addendum	6.3.3.6, 222.1	Physical and Mechanical	
3.6.3.4	Burrs	SSP 50005, Rev. B, NSTS 1700.7B/ISS Addendum	6.3.3.9, 222.1	Physical and Mechanical	
3.6.3.5	Latches	SSP 50005, Rev. B, NSTS 1700.7B/ISS Addendum	6.3.3.5, 222.1	Physical and Mechanical	
3.6.3.6	Levers, Cranks, Hooks, and Controls	SSP 50005, Rev. B, NSTS 1700.7B/ISS Addendum	6.3.3.8, 222.1	Physical and Mechanical	
3.6.3.7	Safety/Lockwire	SSP 50005, Rev. B, NSTS 1700.7B/ISS Addendum	6.3.3.10, 222.1	Physical and Mechanical	
3.6.3.8	Securing Pins	SSP 57000	3.12.9.6	Physical and Mechanical	
3.6.4	Pressure Relief Device Location			Physical and Mechanical	
3.7	Mechanical Interfaces for Crew Restraints and Mobility Aids	N/A	N/A	Physical and Mechanical	Not a requirement.
3.7.1	Hardware Definition	N/A	N/A	Physical and Mechanical	Not a requirement.
3.7.2	Interface Compatibility	SSP 30257:004, Rev. D	All	Physical and Mechanical	
3.8	IVA Transfer Pathway	NSTS 21000-IDD-MDK, SSP 57000	3.9, 3.12.4.1	Physical and Mechanical	
3.9	Orbiter Overhead Window Interfac Requirements	NSTS 21000-IDD-MDK	3.11	Physical and Mechanical	

TABLE B-I TRACEABILITY MATRIX (Sheet 7 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
4	Structural Interfaces	N/A	N/A	Structures/Loads	Not a requirement.
4.1	Operational Loads	N/A	N/A	Structures/Loads	Not a requirement.
4.1.1	Component Frequency	NSTS 21000-IDD-MDK, SSP 57000, SSP 52005	4.1, 3.1.1.4(D) 5.7	Structures/Loads	
4.1.2	Payload Low Frequency Launch and Landing Loads	NSTS 21000-IDD-MDK, Loads AIT	4.1, All	Structures/Loads	Memo #ED26 (95-037)
4.2	Emergency Landing Loads Factors	N/A	N/A	Structures/Loads	Not a requirement.
4.2.1	Middeck	NSTS 21000-IDD-MDK	4.2	Structures/Loads	
4.3	Random Vibration	N/A	N/A	Structures/Loads	Not a requirement.
4.3.1	Random Vibration - MPLM	SSP 57000	3.1.1.2(D)	Structures/Loads	
4.3.2	Random Vibration - Middeck	NSTS 21000-IDD-MDK	4.3	Structures/Loads	
4.4	EXPRESS Rack MDL Location Interface Loads	N/A	N/A	Structures/Loads	Not a requirement.
4.4.1	Single MDL Location Interface Loads	NSTS 21000-IDD-MDK, S683-34526	4.8, 3.2.2.2	Structures/Loads	
4.4.2	Double MDL Location Interface Loads	NSTS 21000-IDD-MDK, S683-34526	4.8 3.2.2.2	Structures/Loads	
4.4.3	Quad MDL Location Interface Loads	S683-34512	3.2.2.2	Structures/Loads	
4.5	On-Orbit Loads	N/A	N/A	Structures/Loads	Not a requirement.
4.5.1	Crew-Induced Loading	SSP 57000 NSTS 21000-IDD-MDK	3.1.1.3(D), 4.4	Structures/Loads	
4.5.2	On-Orbit Low Frequency Loads	SSP 57000	3.1.1.3(B)	Structures/Load	
4.6	EXPRESS Rack Payload Structural Design	N/A	N/A	Structures/Loads	Not a requirement.
4.6.1	Structural Design	SSP 57000, SSP 52005, NSTS 1700.7B/ISS Addendum	3.1.1.5(A) 3.0, 208	Structures/Loads	
4.6.2	Fracture Control	NASA-STD-5003, SSP 52005	All, 5.3	Structures/Loads	
4.7	Acoustics	N/A	N/A	Structures/Loads	Not a requirement.
4.7.1	Lift-Off and Ascent Acoustics	NSTS 21000-IDD-MDK, SSP 57000, SSP 41017	4.7.1, 3.1.1.2(C), 3.2.1.4.1.1	Structures/Loads	

TABLE B-I TRACEABILITY MATRIX (Sheet 8 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
4.7.2	Payload-Generated Acoustic Noise	NSTS 21000-IDD-MDK, SSP 57000	4.7.3, 3.12.3.3	Structures/Loads	Not a requirement.
4.7.2.1	Acoustic Noise Definitions	N/A	N/A	Structures/Loads	Not a requirement.
4.7.2.1.1	Significant Noise Source	SSP 57000	3.12.3.3.1.1	Structures/Loads	Not a requirement.
4.7.2.1.2	Continuous Noise Source	SSP 57000	3.12.3.3.1.2	Structures/Loads	Not a requirement.
4.7.2.1.3	Intermittent Noise Source	SSP 57000	3.12.3.3.1.3	Structures/Loads	Not a requirement.
4.7.2.1.4	Acoustic Reference	SSP 57000	3.12.3.3.1.4	Structures/Loads	Not a requirement.
4.7.2.2	Acoustic Noise Limits	SSP 57000	3.12.3.3.2	Structures/Loads	Derived
4.7.2.2.1	Continuous Noise Limits	SSP 57000	3.12.3.3.2.1	Structures/Loads	Derived
4.7.2.2.2	Intermittent Noise Limits	SSP 57000	3.12.3.3.2.2	Structures/Loads	Derived
4.7.2.2.3	Continuous Noise Sources with Intermittent Noise Features	SSP 57000	3.12.3.3.2.3	Structures/Loads	Derived
4.7.2.2.3A	Continuous Noise Sources with Intermittent Noise Features	SSP 57000	3.12.3.3.2.3	Structures/Loads	Derived
4.7.2.2.3B	Continuous Noise Sources with Intermittent Noise Features	SSP 57000	3.12.3.3.2.3	Structures/Loads	Derived
4.7.2.2.3C	Continuous Noise Sources with Intermittent Noise Features	SSP 57000	3.12.3.3.2.3	Structures/Loads	Derived
4.7.2.3	Sound Power Readings on Payloads	SSP 57000	3.12.3.3.4	Structures/Loads	
4.7.2.4	Acoustic Test Plan for Payloads	SSP 57000	3.12.3.3.5	Structures/Loads	
4.8	Depressurization/Repressurization Requirements	NSTS 1700.7B/ISS Addendum, SSP 57000	208.5, 3.1.1.2(B) 3.1.1.4(B)	Structures/Loads	Not a requirement.
4.8.1	USL, APM, CAM, and JEM Maximum Depressurization/Repressurization Rates	NSTS 1700.7B/ISS Addendum, SSP 57000	208.5, 3.1.1.4(B)	Structures/Loads	
4.8.2	MPLM Maximum Depressurization/ Repressurization Rate	NSTS 1700.7B/ISS Addendum, SSP 57000	208.5, 3.1.1.2(B)	Structures/Loads	
4.8.3	Middeck Maximum Depressurization/ Repressurization Rates	NSTS 21000-IDD-MDK	6.1	Structures/Loads	
4.8.4	Portable Fire Extinguisher (PFE) Discharge Rate	SSP 57000	3.1.1.4(K)	Structures/Loads	

TABLE B-I TRACEABILITY MATRIX (Sheet 9 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
4.9	Ground Handling Environments	KHB 1700.7	All	Structures/Loads	Not a requirement.
4.9.1	Ground Handling Load Factors	Derived SPAH (SLP 2104) Main Volume, KHB 1700.7	5.1.2.1, All	Structures/Loads	
4.9.2	Ground Handling Shock Criteria	Derived SPAH (SLP 2104) Main Volume	5.1.2.2	Structures/Loads	
4.10	Microgravity Disturbances	N/A	N/A	Structures/Loads	Not a requirement (referenc NSTS 21000-IDD-MDK, paragraph 4.1.1
4.10.1	Quiescent Period Payload-Induced Quasi-Steady Accelerations	SSP 57000	3.1.2.1	Structures/Loads	Not a requirement.
4.10.2	Quiescent Period Payload-Induced Transient Acceleration	SSP 57000	3.1.2.2	Structures/Loads	Not a requirement.
4.10.3	Quiescent Period Payload-Induced On-Orbit Vibration	SSP 57000	3.1.2.3	Structures/Loads	Not a requirement.
4.10.3A	Quiescent Period Payload-Induced On-Orbit Vibration	SSP 57000	3.1.2.3	Structures/Loads	Not a requirement.
4.10.3B	Quiescent Period Payload-Induced On-Orbit Vibration	SSP 57000	3.1.2.3	Structures/Loads	Not a requirement.
4.10.4	Angular Momentum Limits			Structures/Loads	
4.10.4A	Angular Momentum Limits			Structures/Loads	
4.10.4B	Angular Momentum Limits			Structures/Loads	
4.10.4C	Angular Momentum Limits			Structures/Loads	
4.10.4D	Angular Momentum Limits			Structures/Loads	
4.10.4E	Angular Momentum Limits			Structures/Loads	
4.10.4F	Angular Momentum Limits			Structures/Loads	
4.10.4G	Angular Momentum Limits			Structures/Loads	
4.10.4.1	Limit Disturbance Induced ISS Attitude Rate			Structures/Loads	
4.10.4.2	Limit Disturbance Induced Control Moment Gyroscope (CMG) Momentum Usage			Structures/Loads	
4.11	Constraints for ARIS EXPRESS Rack Activity	OZ	Derived	Structures/Loads	Derived

TABLE B-I TRACEABILITY MATRIX (Sheet 10 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
5	Thermal/Fluids Interface	N/A	N/A	Thermal/ECS	Not a requirement.
5.1	General Requirements	N/A	N/A	Thermal/ECS	Not a requirement.
5.1.1	External Surface Touch Temperature	N/A	N/A	Thermal/ECS	Not a requirement.
5.1.1A	External Surface Touch Temperature			Thermal/ECS	
5.1.1B	Intentional/Incidental Contact - High Temperature	NSTS 21000-IDD-MDK, NSTS 1700.7B/ISS Addendum	6.2.2, 222.3	Thermal/ECS	Memo #MA92-95-048
5.1.1C	Intentional/Incidental Contact - Low Temperature	NSTS 21000-IDD-MDK, NSTS 1700.7B/ISS Addendum	6.2.2, 222.3	Thermal/ECS	Memo #MA92-95-048
5.1.2	Condensation Prevention	NSTS 21000-IDD-MDK, SSP 50005, Rev. B	6.1, 6.4.3.10	Thermal/ECS	
5.1.2.1	Condensation Prevention (Refrigerators/Freezers)	NSTS 21000-IDD-MDK, SSP 50005, Rev. B	6.1, 6.4.3.10	Thermal/ECS	Derived
5.1.3	Loss of Cooling	NSTS 1700.7B/ISS Addendum	200	Thermal/ECS	
5.1.4	Pressure Relief/Vent Valve Sizing	NSTS 1700.7B/ISS Addendum	208.5	Thermal/ECS	
5.1.5	Pressurized Gas Systems			Thermal/ECS	
5.2	ISS Laboratory (Cabin) Environmental Conditions	NSTS 21000-IDD-MDK, SSP 57000	6.1, 6.2, 3.9	Thermal/ECS	
5.3	Payload Element Cooling	N/A	N/A	Thermal/ELS	Not a requirement.
5.3.1	Payload Heat Dissipation	N/A	N/A	Thermal/ECS	Not a requirement.
5.3.1.1	Passive Cooling	NSTS 21000-IDD-MDK, SSP 57000	6.2.1.2, 3.5.2.12	Thermal/ECS	
5.3.1.1.1	Payload Front Surface Temperature			Thermal/ECS	
5.3.1.1.2	Cabin Air Heat Leak			Thermal/ECS	
5.3.1.1.3	Convective Heat Transfer Coefficient			Thermal/ECS	
5.3.1.2	Active Cabin Air Cooling/Heating Interface	NSTS 21000-IDD-MDK, SSP 57000	6.2.1.3, 3.5.2.13	Thermal/ECS	
5.3.1.2.1	Particulate(s) and Filters/Debris Traps	NSTS 21000-IDD-MDK, S683-34526	6.2.1.4.8, TBD	Thermal/ECS	
5.3.1.3	Avionics Air Cooling	N/A	N/A	Thermal/ECS	Not a requirement.
5.3.1.3.1	Physical Interface	N/A	N/A	Thermal/ECS	Not a requirement.
5.3.1.3.1.1	MDLs	N/A	N/A	Thermal/ECS	Not a requirement.

TABLE B-I TRACEABILITY MATRIX (Sheet 11 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
5.3.1.3.1.2	ISIS Drawers	S683-34526, ISIS-01	3.2.1.1, TBD	Thermal/ECS	
5.3.1.3.1.3	Fans	NSTS 21000-IDD-MDK, ISIS-01, S683-34526	6.2.1.3, 6.2.1.4 TBD, TBD	Thermal/ECS	
5.3.1.3.1.4	Sealing Surfaces	S683-34526	Derived	Thermal/ECS	Derived/G. Day
5.3.1.3.1.5	Maximum Air Leakage Across Payloa Mounting Interface	NSTS 21000-IDD-MDK	Derived	Thermal/ECS	Derived from Middeck Requirements.
5.3.1.3.2	Air Supply Temperature	S683-34526	TBD	Thermal/ECS	Derived/G. Day
5.3.1.3.3	Air Flow Rate	N/A	N/A	Thermal/ECS	Not a requirement.
5.3.1.3.3.1	MDLs	S683-34526	TBD	Thermal/ECS	Derived/G. Day
5.3.1.3.3.2	ISIS Drawers			Thermal/ECS	
5.3.1.3.4	Air Return Temperature	SSP 52000-IDD-PRP, S683-34526	TBD TBD	Thermal/ECS	Derived/G. Day
5.3.1.3.5	Payload Inlet Debris Traps	NSTS 21000-IDD-MDK, S683-34526	6.2.1.3.1, 6.2.1.5.8 TBD	Thermal/ECS	Derived/G. Day
5.3.1.3.6	Maximum Allowable Heat Dissipation	N/A	N/A	Thermal/ECS	Not a requirement.
5.3.1.3.7	Payload Limitations on Heat Conducted to Structure	NSTS 21000-IDD-MDK	6.2.1.3	Thermal/ECS	
5.3.1.4	Middeck Ducted Air Cooling	NSTS 21000-IDD-MDK	6.2.1.5	Thermal/ECS	
5.3.1.4.1	Bay 1 Ducted Air Cooling Capability	N/A	N/A	Thermal/ECS	Not a requirement.
5.3.1.4.1.1	Bay 1 Standard Air Flow Capability	N/A	N/A	Thermal/ECS	Not a requirement.
5.3.1.4.1.2	Bay 2 Ducted Air Cooling Capability	N/A	N/A	Thermal/ECS	Not a requirement.
5.3.1.4.1.2.1	Bay 2 Standard Air Flow Capability	N/A	N/A	Thermal/ECS	Not a requirement.
5.3.1.4.2	Bay 3A Ducted Air Cooling Capability	N/A	N/A	Thermal/ECS	Not a requirement.
5.3.1.4.2.1	Bay 3A Standard Air Flow Capability	N/A	N/A	Thermal/ECS	Not a requirement.
5.3.1.4.3	Payload Limitations on Heat Conducted to Structure	NSTS 21000-IDD-MDK	6.2.1.3	Thermal/ECS	
5.3.1.4.4	Payload Outlet Air Pressure Requirement	NSTS 21000-IDD-MDK	6.2.1.5.4	Thermal/ECS	
5.3.1.4.5	Ducted Payload Air Pressure Requirement	N/A	N/A	Thermal/ECS	Not a requirement.
5.3.1.4.5.1	Single Size MDL Payload Air Coolin Interface	N/A	N/A	Thermal/ECS	Not a requirement.
5.3.1.4.5.2	Double Size MDL Payload Air Coolin Interface	N/A	N/A	Thermal/ECS	Not a requirement.

TABLE B-I TRACEABILITY MATRIX (Sheet 12 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
5.3.1.4.6	Cabin and Avionics Bay Air Mixing Limitations	NSTS 21000-IDD-MDK	6.2.1.5.7	Thermal/ECS	
5.3.1.4.7	Ducted Payload Limitations on Heat Convected o Radiated to Cabin Air	NSTS 21000-IDD-MDK	6.2.1.5.8	Thermal/ECS	
5.3.1.4.8	Maximum Air Leakage Across Payload Mounting Interface Requirement	NSTS 21000-IDD-MDK	6.3.1	Thermal/ECS	
5.3.1.5	Water Cooling Interface Requirements	N/A	N/A	Thermal/ECS	Not a requirement.
5.3.1.5.1	Physical Interface	S683-34526	3.1.2.2.2	Thermal/ECS	Derived
5.3.1.5.2	Fluid Use	SSP 30573	Tables 4.1-1.9.24 to 28	Thermal/ECS	
5.3.1.5.2A	Fluid Use	SSP 30573	Tables 4.1-1.9.24 to 28	Thermal/ECS	
5.3.1.5.2B	Fluid Use	SSP 30573	Tables 4.1-1.9.24 to 28	Thermal/ECS	
5.3.1.5.2C	Fluid Use	SSP 30573	Tables 4.1-1.9.24 to 28	Thermal/ECS	
5.3.1.5.2D	Fluid Use	SSP 57000	3.11.2D	Thermal/ECS	
5.3.1.5.2E	Fluid Use	SSP 57000	3.11.2E	Thermal/ECS	
5.3.1.5.3	Water Quantity	SSP 57001	3.3.1.7	Thermal/ECS	Derived.
5.3.1.5.4	Thermal Expansion	SSP 57000	3.5.12(B)	Thermal/ECS	
5.3.1.5.4A	Thermal Expansion			Thermal/ECS	
5.3.1.5.4B	Thermal Expansion			Thermal/ECS	
5.3.1.5.4C	Thermal Expansion			Thermal/ECS	
5.3.1.5.5	Water Loop Pressure Drop	S683-34526	3.1.2.2.2	Thermal/ECS	Derived/G. Day
5.3.1.5.6	QD Air Inclusion	SSP 57000, 683-16348	3.5.1.10	Thermal/ECS	Derived
5.3.1.5.7	Leak Rate	SSP 57000, S683-34526	3.5.1.9, TBD	Thermal/ECS	Derived
5.3.1.5.8	Water Coolant Flow Rate	S683-34526	3.1.2.2.2	Thermal/ECS	Derived
5.3.1.5.9	Water Coolant Supply Temperature	SSP 57000, S683-34526	3.5.1.5, 3.1.2.2.2	Thermal/ECS	Derived
5.3.1.5.10	Water Coolant Return Temperature	SSP 57000, S683-34526	3.5.1.6, 3.1.2.2.2	Thermal/ECS	Derived
5.3.1.5.11	Maximum Water Coolant System Pressure	SSP 57000, S683-34526	3.5.1.7 3.7.2(E)	Thermal/ECS	
5.3.2	USL/APM/JEM/Centrifuge Accommodation Module (CAM) Unique Thermal Control Interfac Requirements	SSP 57000	3.5.1.2.2, 3.5.1.3.2, 3.5.1.4.2, 3.5.1.5.2, 3.5.1.6.2, 3.5.1.7.3, 3.5.1.8.3	Thermal/ECS	Derived

TABLE B-I TRACEABILITY MATRIX (Sheet 13 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
5.4	Vacuum Exhaust System/Waste Gas System Interface Requirements (USL, APM, JEM)	N/A	N/A	Thermal/Vacuum	Not a requirement.
5.4.1	Physical Interface (USL, APM, JEM)	S683-34526	3.7.2(G)	Thermal/Vacuum	
5.4.2	Input Pressure Limit (USL, APM, JEM)	SSP 57000	3.6.1.2	Thermal/Vacuum	Derived
5.4.3	Input Temperature Limit (USL, APM, JEM)	SSP 57000	3.6.1.3	Thermal/Vacuum	Derived
5.4.4	Input Dewpoint Limit (USL, APM, JEM)	SSP 57000	3.6.1.4	Thermal/Vacuum	Derived
5.4.5	Vacuum Exhaust System (VES)/Waste Gas System (WGS) MDP	SSP 57000	3.6.1.2A	Thermal/Vacuum	
5.4.6	Leak Rate (USL, APM, JEM)	SSP 57000	TBD	Thermal/Vacuum	Derived - Not in the SSP 57000 or 57001
5.4.7	Acceptable Effluents (USL, APM, JEM)	SSP 57000, S683-34526	3.6.1.5, 3.1.1	Thermal/Vacuum	Derived
5.4.7.1	Acceptable Gases (USL, APM, JEM)	SSP 57000	3.6.1.5.1	Thermal/Vacuum	Derived
5.4.7.1A	Acceptable Gases (USL, APM, JEM)	SSP 57000	3.6.1.5.1	Thermal/Vacuum	Derived
5.4.7.1B	Acceptable Gases (USL, APM, JEM)	SSP 57000	3.6.1.5.1	Thermal/Vacuum	Derived
5.4.7.1C	Acceptable Gases (USL, APM, JEM)	SSP 57000	3.6.1.5.1	Thermal/Vacuum	Derived
5.4.7.1D	Acceptable Gases (USL, APM, JEM)	SSP 57000	3.6.1.5.1	Thermal/Vacuum	Derived
5.4.7.2	External Contamination Control (USL, APM, JEM)	SSP 57000, SSP 30426	3.6.1.5.2, 3.4	Thermal/Vacuum	Derived
5.4.7.3	Incompatible Exhaust Gases (USL, APM, JEM)	SSP 57000	3.6.1.5.3	Thermal/Vacuum	
5.4.7.3A	Incompatible Exhaust Gases (USL, APM, JEM)	SSP 57000	3.6.1.5.3	Thermal/Vacuum	
5.4.7.3B	Incompatible Exhaust Gases (USL, APM, JEM)	SSP 57000	3.6.1.5.3	Thermal/Vacuum	
5.4.8	Utility Control			Thermal/Vacuum	
5.5	Gaseous Nitrogen (GN_2) Interface Requirements	N/A	N/A	Thermal/GN_2	Not a requirement.
5.5.1	Physical Interface	S683-34526	3.7.2(F)	Thermal/GN_2	
5.5.2	Utility Control	SSP 57000	3.7.1.1	Thermal/GN_2	Derived
5.5.3	GN_2 System MDP	SSP 57000	3.7.1.2	Thermal/GN_2	
5.5.4	Interface Pressure (USL, APM)	SSP 57000	3.7.1.2, 3.7.1.5	Thermal/GN_2	
5.5.5	Temperature	SSP 57000	3.7.1.3	Thermal/GN_2	
5.5.6	Leak Rate	SSP 57000	3.7.1.4	Thermal/GN_2	
5.5.7	GN_2 Characteristics	SSP 30573	All	Thermal/GN_2	Derived - Not in SSP 57000 or SSP 57001
5.5.7A	GN_2 Characteristics			Thermal/GN_2	
5.5.7B	GN_2 Characteristics			Thermal/GN_2	
5.5.7C	GN_2 Characteristics			Thermal/GN_2	

TABLE B-I TRACEABILITY MATRIX (Sheet 14 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
6	Electrical Power Interfaces	N/A	N/A	Electrical/Power	Not a requirement.
6.1	Electrical Power/Energy	N/A	N/A	Electrical/Power	Not a requirement.
6.1.1	Baseline Power Allocation	N/A	N/A	Electrical/Power	Not a requirement.
6.1.2	Shuttle/Middeck Power and Voltage	NSTS 21000-IDD-MDK	7.2.1, 7.3.1	Electrical/Power	
6.2	EXPRESS Rack dc Power Characteristics	N/A	N/A	Electrical/Power	Not a requirement.
6.2.1	28 Vdc Power and Voltage	N/A	N/A	Electrical/Power	Not a requirement.
6.2.1.1	Voltage Levels	S683-34526, S683-46314	3.7.6, All	Electrical/Power	
6.2.1.2	Output Impedance	N/A	N/A	Electrical/Power	Not a requirement.
6.2.1.3	Reverse Current	S683-46314	All	Electrical/Power	
6.2.1.4	Reverse Energy	S683-46314	All	Electrical/Power	
6.2.1.5	Soft Start/Stop	N/A	N/A	Electrical/Power	Not a requirement.
6.2.2	Overload Protection	S683-46314	All	Electrical/Power	
6.2.2.1	Overload Protection Device	NSTS 1700.7B/ISS Addendum	213.1	Electrical/Power	Derived.
6.2.2.1.1	Device Accessibility	SSP 57000	3.12.9.1.4.1	Electrical/Power	
6.2.2.1.2	Location	SSP 57000	3.12.9.1.4.3	Electrical/Power	
6.2.2.1.3	Device Identification	SSP 57000	3.12.9.1.4.4	Electrical/Power	
6.2.2.1.4	Extractor-Type Fuse Holder	SSP 57000	3.12.9.1.4.2	Electrical/Power	
6.2.3	Current Limiting	N/A	N/A	Electrical/Power	Not a requirement.
6.2.3A	Current Limiting	S683-46314	3.2.1.6.8.4	Electrical/Power	
6.2.3B	Current Limiting	S683-46314	3.2.1.6.8.1.1, 3.2.1.6.8.1.3	Electrical/Power	
6.2.3C	Current Limiting	NSTS 1700.7B, Addendum, NSTS 21000-IDD-MDK	NSTS 18798(A) TM102179, 7.2.1.4	Electrical/Power	
6.2.3D	Current Limiting	NSTS 1700.7B, Addendum	NSTS 18798(A) TM102179	Electrical/Power	
6.3	Ripple and Transient Spike (Repetitive) Limits - Shuttle/Middeck	N/A	N/A	Electrical/Power	Not a requirement.

TABLE B-I TRACEABILITY MATRIX (Sheet 15 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
6.3.1	In-Flight dc Power Bus Ripple at the Interface - Shuttle/Middeck	N/A	N/A	Electrical/Power	Not a requirement.
6.3.1A	In-Flight dc Power Bus Ripple at the Interface - Shuttle/Middeck	NSTS 21000-IDD-MDK	7.2.2(A.1)	Electrical/Power	
6.3.1B	In-Flight dc Power Bus Ripple at the Interface - Shuttle/Middeck	NSTS 21000-IDD-MDK	7.2.2(A.2)	Electrical/Power	
6.3.2	In-Flight dc Power Transient Spikes (Repetitive) - Shuttle/Middeck	NSTS 21000-IDD-MDK	7.2.2(B)	Electrical/Power	
6.3.3	Ground dc Power - Shuttle/Middeck	NSTS 21000-IDD-MDK	7.2.2(C)	Electrical/Power	
6.3.3A	Ground dc Power - Shuttle/Middeck	NSTS 21000-IDD-MDK	7.2.2(C.1)	Electrical/Power	
6.3.3B	Ground dc Power - Shuttle/Middeck	NSTS 21000-IDD-MDK	7.2.2(C.2)	Electrical/Power	
6.3.3C	Ground dc Power - Shuttle/Middeck	NSTS 21000-IDD-MDK	7.2.2(C.3)	Electrical/Power	
6.3.4	Ac Power Characteristics - Shuttle/Middeck	NSTS 21000-IDD-MDK	7.3	Electrical/Power	
6.4	Ripple and Transient Spikes (Repetitive) Limits - ISS	S683-46314	All	Electrical/Power	
6.4.1	Startup Condition Spikes	S683-46314	All	Electrical/Power	
6.4.2	Differential Mode PARD (Noise/Ripple)	S683-46314 SSP 30237	3.2.1.6.1.6 CS06	Electrical/Power	
6.5	Limitations on EXPRESS Rack Payload Utilization of Electrical Power	N/A	N/A	Electrical/Power	Not a requirement.
6.5.1	On-Orbit Transfer	N/A	N/A	Electrical/Power	Not a requirement.
6.5.2	EXPRESS Rack Payload Electrical Safety/Hazards	N/A	N/A	Electrical/Power	Not a requirement.
6.5.2.1	Batteries	NSTS 1700.7B/ISS Addendum, NSTS 20793	213.2, All	Electrical/Power	
6.5.2.2	Safety-Critical Circuits	N/A	N/A	Electrical/Power	Not a requirement.
6.5.2.2A	Safety-Critical Circuits	NSTS 1700.7B/ISS Addendum	NSTS 18798A, ET12-90-115	Electrical/Power	
6.5.2.2B	Safety-Critical Circuits	NSTS 1700.7B/ISS Addendum, SSP 30237	NSTS 18798A, 3.2.4	Electrical/Power	

TABLE B-I TRACEABILITY MATRIX (Sheet 16 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
6.5.2.2C	Safety-Critical Circuits	NSTS 1700.7B/ISS Addendum	NSTS 18798A, TJ2-87-136	Electrical/Power	
6.5.2.3	Electrical Hazards	NSTS 1700.7B/ISS Addendum, SSP 50005, Rev. B	All, 6.4	Electrical/Power	
6.5.2.3A	Electrical Hazards	NSTS 1700.7B/ISS Addendum, SSP 50005, Rev. B	All, 6.4	Electrical/Power	
6.5.2.3B	Electrical Hazards	NSTS 1700.7B/ISS Addendum, SSP 50005, Rev. B	All, 6.4	Electrical/Power	
6.5.2.3C	Electrical Hazards	NSTS 1700.7B/ISS Addendum, SSP 50005, Rev. B	All, 6.4	Electrical/Power	
6.5.2.3D	Electrical Hazards	NSTS 1700.7B/ISS Addendum, SSP 50005, Rev. B	All, 6.4	Electrical/Power	
6.5.2.3E	Electrical Hazards	NSTS 1700.7B/ISS Addendum, SSP 50005, Rev. B	All, 6.4	Electrical/Power	
6.5.3	Power Loss	NSTS 1700.7B/ISS Addendum	200.4(A)	Electrical/Power	Derived
6.5.3.1	Automatic Starting After Power Loss	SSP 57000	3.12.9.1.5.1	Electrical /Power	
6.5.4	Emergency Operational Modes	NSTS 1700.7B/ISS Addendum	200.4(A)	Electrical/Power	Derived
6.5.5	Payload Element Activation/Deactivatio and Isolation	NSTS 1700.7B/ISS Addendum	NSTS 18798A, MA3-94-002	Electrical/Power	Derived
6.6	Electrical Connectors	N/A	N/A	Electrical/Power	Not a requirement.
6.6.1	Connector Pins/Sockets	NSTS 1700.7B/ISS Addendum	NSTS 18798A, MA3-94-002	Electrical/Power	
6.6.2	Electrical Connector Mating/Demating (Unpowered)	NSTS 1700.7B/ISS Addendum	NSTS 18798A, MA3-94-002	Electrical/Power	
6.6.3	Electrical Connector Mating/Demating (Powered)	NSTS 1700.7B/ISS Addendum	NSTS 18798A, MA2-97-093	Electrical/Power	
6.6.3A	Electrical Connector Mating/Demating (Powered)	NSTS 1700.7B/ISS Addendum	NSTS 18798A, MA2-97-093	Electrical/Power	
6.6.3B	Electrical Connector Mating/Demating (Powered)	NSTS 1700.7B/ISS Addendum	NSTS 18798A, MA2-97-093	Electrical/Power	
6.6.3B(1)	Electrical Connector Mating/Demating (Powered)	NSTS 1700.7B/ISS Addendum	NSTS 18798A, MA2-97-093	Electrical/Power	
6.6.3B(2)	Electrical Connector Mating/Demating (Powered)	NSTS 1700.7B/ISS Addendum	NSTS 18798A, MA2-97-093	Electrical/Power	
6.6.3B(3)	Electrical Connector Mating/Demating (Powered)	NSTS 1700.7B/ISS Addendum	NSTS 18798A, MA2-97-093	Electrical/Power	

TABLE B-I TRACEABILITY MATRIX (Sheet 17 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
6.6.3B(4)	Electrical Connector Mating/Demating (Powered)	NSTS 1700.7B/ISS Addendum	NSTS 18798A, MA2-97-093	Electrical/Power	
6.6.4	Electrical Connector Mismating Prevention	SSP 50005B, NSTS 1700.7B/ISS Addendum	6.4.3.7(A) 221	Electrical/Power	
6.6.4A	Electrical Connector Mismating Prevention	SSP 50005B, NSTS 1700.7B/ISS Addendum	6.4.3.7(A) 221	Electrical/Power	
6.6.4B	Electrical Connector Mismating Prevention	SSP 50005B, NSTS 1700.7B/ISS Addendum	6.4.3.7(A) 221	Electrical/Power	
6.6.4C	Electrical Connector Mismating Prevention	SSP 50005B, NSTS 1700.7B/ISS Addendum	6.4.3.7(A) 221	Electrical/Power	
6.6.4D	Electrical Connector Mismating Prevention	SSP 50005B, NSTS 1700.7B/ISS Addendum	6.4.3.7(A) 221	Electrical/Power	
6.6.5	Mechanical Protection	SSP 50005B	6.4.3.7(B)	Electrical/Power	
6.6.6	Current Draw Labeling	PSRP Action Item	PSRP	Electrical/Power	Derived

TABLE B-I TRACEABILITY MATRIX (Sheet 18 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
7	Electromagnetic Compatibility (EMC)	N/A	N/A	Electrical/EMC	Not a requirement.
7.1	Circuit EMC Classifications	NSTS 21000-IDD-MDK, SSP 30237	8.1, 8.2, and 8.3, All	Electrical/EMC	
7.2	Shuttle-Produced Interference Environment	N/A	N/A	Electrical/EMC	Not a requirement.
7.2.1	Conducted Interference	NSTS 21000-IDD-MDK	8.2.1	Electrical/EMC	
7.2.2	Radiated Interference - Shuttle/Middeck	NSTS 1700.7B, ISS Addendum, NSTS 21000-IDD-MDK	212, 8.2.2	Electrical/EMC	
7.2.2A	Radiated Interference - Shuttle/Middeck	NSTS 1700.7B/ISS Addendum, NSTS 21000-IDD-MDK	212, 8.2.2(A)	Electrical/EMC	
7.2.2B	Radiated Interference - Shuttle/Middeck	NSTS 1700.7B, ISS Addendum, NSTS 21000-IDD-MDK	212, 8.2.2(B)	Electrical/EMC	
7.2.2C	Radiated Interference - Shuttle/Middeck	NSTS 1700.7B, ISS Addendum, NSTS 21000-IDD-MDK	212, 8.2.2(C)	Electrical/EMC	
7.2.2D	Radiated Interference - Shuttle/Middeck	NSTS 1700.7B, ISS Addendum, NSTS 21000-IDD-MDK	212, 8.2.2(C)	Electrical/EMC	
7.2.2E	Radiated Interference - Shuttle/Middeck	NSTS 1700.7B, ISS Addendum, NSTS 21000-IDD-MDK	212, 8.2.2(C)	Electrical/EMC	
7.2.2.1	Shuttle-Produced Wireless Crew Communication System (WCCS) Radiated Electric Fields	NSTS 21000-IDD-MDK	8.2.2.1	Electrical/EMC	
7.3	Electromagnetic Compatibility	NSTS 21000-IDD-MDK	8.2 and 8.3	Electrical/EMC	
7.3.1	Emission and Susceptibility Limits and Test Methods	MSFC EMI/EMC Group	N/A	Electrical/EMC	
7.3.1.1	Compatibility	MSFC EMI/EMC Group	N/A	Electrical/EMC	
7.3.1.2	Applicability	MSFC EMI/EMC Group	N/A	Electrical/EMC	
7.3.1.3	Conducted Emissions	MSFC EMI/EMC Group	N/A	Electrical/EMC	
7.3.1.3.1	CE01, Conducted Emissions	MSFC EMI/EMC Group	N/A	Electrical/EMC	
7.3.1.3.2	CE01 Limits	MSFC EMI/EMC Group	N/A	Electrical/EMC	
7.3.1.3.3	CE03, Conducted Emissions	MSFC EMI/EMC Group	N/A	Electrical/EMC	
7.3.1.3.4	CE03 Limits	MSFC EMI/EMC Group	N/A	Electrical/EMC	
7.3.1.3.5	CE07, Conducted Emissions	MSFC EMI/EMC Group	N/A	Electrical/EMC	
7.3.1.3.6	CE07 Limits	MSFC EMI/EMC Group	N/A	Electrical/EMC	
7.3.1.4	Conducted Susceptibility	MSFC EMI/EMC Group	N/A	Electrical/EMC	

TABLE B-I TRACEABILITY MATRIX (Sheet 19 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
7.3.1.4.1	CS01, Conducted Susceptibility	MSFC EMI/EMC Group	N/A	Electrical/EMC	
7.3.1.4.2	CS01 Limits	MSFC EMI/EMC Group	N/A	Electrical/EMC	
7.3.1.4.3	CS02, Conducted Susceptibility	MSFC EMI/EMC Group	N/A	Electrical/EMC	
7.3.1.4.4	CS02 Limits	MSFC EMI/EMC Group	N/A	Electrical/EMC	
7.3.1.4.5	CS06, Conducted Susceptibility	MSFC EMI/EMC Group	N/A	Electrical/EMC	
7.3.1.4.6	CS06 Limits	MSFC EMI/EMC Group	N/A	Electrical/EMC	
7.3.1.4.6A	CS06 Limits	MSFC EMI/EMC Group	N/A	Electrical/EMC	
7.3.1.4.6B	CS06 Limits	MSFC EMI/EMC Group	N/A	Electrical/EMC	
7.3.1.5	Radiated Emissions	MSFC EMI/EMC Group	N/A	Electrical/EMC	
7.3.1.5.1	RE02, Radiated Emissions	MSFC EMI/EMC Group	N/A	Electrical/EMC	
7.3.1.5.2	Applicability	MSFC EMI/EMC Group	N/A	Electrical/EMC	
7.3.1.5.3	RE02 Limits	MSFC EMI/EMC Group	N/A	Electrical/EMC	
7.3.1.5.4	Narrowband Electric Field Emissions	MSFC EMI/EMC Group	N/A	Electrical/EMC	
7.3.1.6	Radiated Susceptibility	MSFC EMI/EMC Group	N/A	Electrical/EMC	
7.3.1.6.1	RS02, Radiated Susceptibility	MSFC EMI/EMC Group	N/A	Electrical/EMC	
7.3.1.6.2	Applicability	MSFC EMI/EMC Group	N/A	Electrical/EMC	
7.3.1.6.3	RS02 Limits	MSFC EMI/EMC Group	N/A	Electrical/EMC	
7.3.1.6.3A	RS02 Limits	MSFC EMI/EMC Group	N/A	Electrical/EMC	
7.3.1.6.3B	RS02 Limits	MSFC EMI/EMC Group	N/A	Electrical/EMC	
7.3.1.7	RS03, Radiated Susceptibility	MSFC EMI/EMC Group	N/A	Electrical/EMC	
7.3.1.7.1	Applicability	MSFC EMI/EMC Group	N/A	Electrical/EMC	
7.3.1.7.2	RS03 Limits	MSFC EMI/EMC Group	N/A	Electrical/EMC	
7.3.2	Electrostatic Discharge	N/A	N/A	Electrical/EMC	Not a requirement.
7.3.2.1	ESD Compatibility	SSP 30312, Rev. E NSTS 21000-IDD-MDK	3.13, 8.2.2(C)	Electrical/EMC	
7.3.2.2	ESD Labeling	SSP 30312, Rev. E MIL-STD-1686	3.13, Labeling-Only	Electrical/EMC	
7.3.2.3	Corona	MSFC-STD-531	All	Electrical/EMC	Derived
7.3.2.4	Lightning			Electrical/EMC	
7.4	Payload-Produced Interferenc Environment - Shuttle	N/A	N/A	Electrical/EMC	Not a requirement.

TABLE B-I TRACEABILITY MATRIX (Sheet 20 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
7.4.1	Payload-Produced Conducted Noise - Shuttle	N/A	N/A	Electrical/EMC	Not a requirement.
7.4.1A	Payload-Produced Conducted Noise - Shuttle	NSTS 1700.7B/ISS Addendum, NSTS 21000-IDD-MDK	212, 8.3.1	Electrical/EMC	
7.4.1B	Payload-Produced Conducted Noise - Shuttle	NSTS 1700.7B/ISS Addendum, NSTS 21000-IDD-MDK	212, 8.3.1	Electrical/EMC	
7.4.1C	Payload-Produced Conducted Noise - Shuttle	NSTS 1700.7B/ISS Addendum, NSTS 21000-IDD-MDK	212, 8.3.1	Electrical/EMC	
7.4.2	Payload-Produced Radiated Fields - Shuttle	N/A	N/A	Electrical/EMC	Not a requirement.
7.4.2A	Payload-Produced Radiated Fields - Shuttle	NSTS 1700.7B/ISS Addendum, NSTS 21000-IDD-MDK	212, 8.3.2(A)	Electrical/EMC	
7.4.2B	Payload-Produced Radiated Fields - Shuttle	NSTS 1700.7B/ISS Addendum, NSTS 21000-IDD-MDK	212, 8.3.2(B)	Electrical/EMC	
7.4.2C	Payload-Produced Radiated Fields - Shuttle	NSTS 1700.7B/ISS Addendum, NSTS 21000-IDD-MDK	212, 8.3.2(C)	Electrical/EMC	
7.4.2D	Payload-Produced Radiated Fields - Shuttle	NSTS 1700.7B/ISS Addendum, NSTS 21000-IDD-MDK	212, 8.3.2(D)	Electrical/EMC	
7.4.3	Magnetic Fields for EXPRESS Rack Payloads in the ISS	N/A	N/A	Electrical/EMC	Not a requirement.
7.4.3.1	Alternating Current (ac) Magnetic Fields for EXPRESS Rack Payloads in the ISS	SSP 57000, SSP 30237, SSP 30238	3.2.4.6, All All	Electrical/EMC	
7.4.3.2	Direct Current (dc) Magnetic Fields fo EXPRESS Rack Payloads in the ISS	SSP 57000, SSP 30237, SSP 30238	3.2.4.7 All All	Electrical/EMC	
7.5	Avionics Electrical Compatibility - Shuttle and ISS	N/A	N/A	Electrical/EMC	Not a requirement.
7.5.1	Electrical Bonding	NSTS 1700.7B/ISS Addendum, NSTS 21000-IDD-MDK, SSP 57000	213, 8.4.1, 3.2.4.2	Electrical/EMC	SSP 30245, Rev. B
7.5.1A	Fault Current Bond - Class C	NSTS 1700.7B/ISS Addendum, NSTS 21000-IDD-MDK, SSP 57000	213, 8.4.1(1), 3.2.4.2	Electrical/EMC	SSP 30245, Rev. B
7.5.1B	Shock Hazard - Cla	NSTS 1700.7B/ISS Addendum, SSP 57000	213, 3.2.4.2	Electrical/EMC	SSP 30245, Rev. B

TABLE B-I TRACEABILITY MATRIX (Sheet 21 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
7.5.1C	Radio Frequency (RF) Bond - Class R	NSTS 1700.7B/ISS Addendum, NSTS 21000-IDD-MDK, SSP 57000	213, 8.4.1(2), 3.2.4.2	Electrical/EMC	SSP 30245, Rev. B
7.5.1D	Static Bond - Class S	NSTS 1700.7B/ISS Addendum, NSTS 21000-IDD-MDK, SSP 57000	213, 8.4.1(3), 3.2.4.2	Electrical/EMC	SSP 30245, Rev. B
7.5.1.1	Electrical Bonding of Payload Hardware	NSTS 1700.7B/ISS Addendum, NSTS 21000-IDD-MDK, SSP 57000	213, 8.4.1.1, 3.2.4.2	Electrical/EMC	SSP 30245, Rev. B
7.5.1.1.1	Redundant Bond Paths	NSTS 18798 MA2-99-142	All	Electrical	
7.5.1.2	Electrical Bonding of Payload Structures	N/A	N/A	Electrical/EMC	Not a requirement.
7.5.1.2.1	Payload-to-EXPRESS Rack Main Bond	N/A	N/A	Electrical/EMC	Not a requirement.
7.5.1.2.1.1	Primary Payload Power Connector Bond	NSTS 1700.7B/ISS Addendum, NSTS 21000-IDD-MDK, SSP 57000	213, 8.4.1.2.1.1, 3.2.4.2	Electrical/EMC	SSP 30245, Rev. B, MIL-B-5087B
7.5.1.2.1.2	Payload-to-EXPRESS Rack Bond Strap	NSTS 1700.7B/ISS Addendum, NSTS 21000-IDD-MDK, SSP 57000	213, 8.4.1.2.1.2, 3.2.4.2	Electrical/EMC	SSP 30245, Rev. B, MIL-B-5087B
7.5.1.2.1.3	Payload-to-EXPRESS Rack Mated Surface Bond	NSTS 1700.7B/ISS Addendum, NSTS 21000-IDD-MDK, SSP 57000	213, 8.4.1.2.1.3, 3.2.4.2	Electrical/EMC	SSP 30245, Rev. B, MIL-B-5087B MIL-C-5541 (Class 3)
7.5.1.2.2	Payload-to-EXPRESS Rack and Fluid Line Bonding	NSTS 1700.7B/ISS Addendum, NSTS 21000-IDD-MDK, SSP 57000	213,, 8.4.1.2.2 3.2.4.2	Electrical/EMC	SSP 30245, Rev. B, MIL-B-5087B
7.5.2	Circuit Reference Symbols	N/A	N/A	Electrical/EMC	Not a requirement.
7.6	Power Circuit Isolation and Grounding	N/A	N/A	Electrical/EMC	Not a requirement.
7.6.1	EXPRESS Rack 28 Vdc Primary Power Bus Isolation	NSTS 1700.7B/ISS Addendum, NSTS 21000-IDD-MDK, SSP 30240	213, 8.5.1, 3.2.1.2	Electrical/EMC	
7.6.2	Dc Power Ground Reference	NSTS 1700.7B/ISS Addendum, NSTS 21000-IDD-MDK, SSP 30240	213, 8.5.1, 3.2.1.2	Electrical/EMC	
7.6.3	Payload Secondary Power Isolation and Grounding	NSTS 1700.7B/ISS Addendum, NSTS 21000-IDD-MDK, SSP 30240	213, 220, 8.5, 3.2.1.2	Electrical/EMC	

TABLE B-I TRACEABILITY MATRIX (Sheet 22 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
7.6.4	GSE Isolation and Grounding	NSTS 21000-IDD-MDK, SSP 30240	8.5.4, 3.2.1.2	Electrical/EMC	
7.7	Signal Isolation and Grounding Requirements	N/A	N/A	Electrical/EMC	Not a requirement.
7.7.1	Ethernet	IEEE 802.3	All	Electrical/EMC	
7.7.2	RS-422	S683-34526	3.1.2.2.3	Electrical/EMC	
7.7.3	SSPCM Analog Grounding	S683-34526	3.1.2.2.3	Electrical/EMC	
7.7.4	SSPCM Discrete	EIA/RS-170	All	Electrical/EMC	
7.7.5	Video	NSTS 21000-IDD-MDK, SSP 30237	8.1 and 8.3, TBD	Electrical/EMC	
7.7.6	Shield References			Electrical/EMC	

TABLE B-I TRACEABILITY MATRIX (Sheet 23 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
8	Electrical Wiring Interface	N/A	N/A	Electrical/EMC	Not a requirement.
8.1	General	NSTS 21000-IDD-MDK, SSP 30242	8.1 & 8.3, All	Electrical/Cabling	
8.1.1	Connector/Pin Interfaces	NSTS 21000-IDD-MDK	9.1	Electrical/Cabling	
8.1.1.1	MDLs/MDL Replacement	S683-34526	3.3.1.4	Electrical/Cabling	
8.1.1.1.1	Previously Flown (Shuttle) MDLs/MDL Replacement			Electrical/Cabling	
8.1.1.2	ISIS Drawers	S683-34526	3.3.1.4	Electrical/Cabling	
8.1.2	Approved Connectors for EXPRESS Rack Payload Use	S683-34526, NSTS 21000-IDD-MDK	3.3.1.4, 9.1.2	Electrical/Cabling	
8.2	Cable Schematics	N/A	N/A	Electrical/Cabling	Not a requirement.

TABLE B-I TRACEABILITY MATRIX (Sheet 24 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
9	Command and Data Handling (C&DH) Interfaces	N/A	N/A	C&DH/422	Not a requirement.
9.1	RS-422 Communications	N/A	N/A	C&DH/422	Not a requirement.
9.1.1	Signal Characteristics	TIA/EIA 422B	All	C&DH/422	
9.1.2	Telemetry Format	D683-43525	4.5.4	C&DH/422	Also Section 11.
9.1.3	Request/Command Format	D683-43525	4.5.3	C&DH/422	Also Section 11.
9.1.4	Processing Requirements	D683-43525	TBD	C&DH/422	
9.1.5	Connector/Pin Interface	N/A	N/A	C&DH/422	Not a requirement.
9.1.5.1	MDLs/MDL Replacements	683-46403	Sheet 3	C&DH/422	
9.1.5.2	ISIS Drawers	683-46403	Sheet 2	C&DH/422	
9.2	Ethernet Communications	N/A	N/A	C&DH/Ethernet	Not a requirement.
9.2.1	Signal Characteristics	IEEE 802.3 (10base-T, Section); TCP/IP	Chapters 13, 14	C&DH/Ethernet	
9.2.2	Communications Protocol	D683-43525-1	3.1.3.1.4	C&DH/Ethernet	Also Section 11.
9.2.3	Telemetry Format	IEEE 802.3 (10base-T, Section); TCP/IP, D683-43525-1	3.3.2.1.2.1, TBD	C&DH/Ethernet	Also Section 11.
9.2.4	Request/Command Format	IEEE 802.3 (10base-T, Section); TCP/IP, D683-43525-1	3.3.2.1.2.1, TBD	C&DH/Ethernet	Also Section 11.
9.2.5	Processing Requirements	D683-43525	TBD	C&DH/Ethernet	
9.2.6	Connector/Pin Interface	N/A	N/A	C&DH/Ethernet	Not a requirement.
9.2.6.1	MDLs/MDL Replacements	683-46403	Sheet 3	C&DH/Ethernet	
9.2.6.2	ISIS Drawers	683-46403	Sheet 2	C&DH/Ethernet	
9.2.7	Communications to Laptop	N/A	N/A	C&DH/Ethernet	Not a requirement.
9.3	Analog Communications	N/A	N/A	C&DH/Analog	Not a requirement. (SSPCM Interface)
9.3.1	Signal Characteristics	683-46314	3.2.1.9.2.1	C&DH/Analog	
9.3.2	Analog Driver Characteristics	683-46314	TBD	C&DH/Analog	
9.3.3	Connector/Pin Interface	N/A	N/A	C&DH/Analog	Not a requirement.
9.3.3.1	MDLs/MDL Replacement	683-46403	Sheet 3	C&DH/Analog	
9.3.3.2	ISIS Drawers	683-46403	Sheet 2	C&DH/Analog	

TABLE B-I TRACEABILITY MATRIX (Sheet 25 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
9.4	Discrete Communications	N/A	N/A	C&DH/Discrete	Not a requirement. (SSPCM Interface)
9.4.1	Discrete Signal Characteristics	N/A	N/A	C&DH/Discrete	Not a requirement.
9.4.1.1	Discrete Output Low Level	683-46314	3.2.1.9.1.1	C&DH/Discrete	
9.4.1.2	Discrete Output High Level	683-46314	3.2.1.9.1.2	C&DH/Discrete	
9.4.1.3	Discrete Output Maximum Fault Current	683-46314	3.2.1.9.1.3	C&DH/Discrete	
9.4.1.4	Discrete Input Low Level	683-46314	3.2.1.9.1.4	C&DH/Discrete	
9.4.1.5	Discrete Input High Level	683-46314	3.2.1.9.1.5	C&DH/Discrete	
9.4.1.6	Discrete Input Maximum Fault Voltage	683-46314	3.2.1.9.1.6	C&DH/Discrete	
9.4.2	Discrete Driver and Receiver Characteristics	683-46314	TBD	C&DH/Discrete	
9.4.3	Connector/Pin Interface	N/A	N/A	C&DH/Discrete	Not a requirement.
9.4.3.1	MDLs/MDL Replacement	683-46403	Sheet 3	C&DH/Discrete	
9.4.3.2	ISIS Drawers	683-46403	Sheet 2	C&DH/Discrete	
9.5	Continuity Discrete Jumper	683-46403	Sheet 2	C&DH/PPCB	
9.6	Point-to-Point Communications Bus (PPCB)	683-46403	Sheets 2 & 3	C&DH/PPCB	
9.7	Video	N/A	N/A	C&DH/Video	Not a requirement.
9.7.1	Payload Video Characteristics	SMPTE 170M, SSP 57000	All, 3.4.1.1	C&DH/Video	
9.7.1.1	Input Impedance	683-46300	TBD	C&DH/Video	Exception to standard.
9.7.1.2	Sync Tip	SMPTE 170M, 683-46300	All, TBD	C&DH/Video	Exception to standard.
9.7.1.3	Blanking Level	SMPTE 170M, 683-46300	All, TBD	C&DH/Video	Exception to standard.
9.7.1.4	White Reference	SMPTE 170M, 683-46300	All, TBD	C&DH/Video	Exception to standard.
9.7.2	Deviations to Video Standard			C&DH/Video	
9.7.2A	Deviations to Video Standard			C&DH/Video	
9.7.2B	Deviations to Video Standard			C&DH/Video	
9.7.2C	Deviations to Video Standard			C&DH/Video	
9.7.2D	Deviations to Video Standard			C&DH/Video	
9.7.2E	Deviations to Video Standard			C&DH/Video	
9.7.3	Connector/Pin Interface	683-46403	Sheets 2 & 3	C&DH/Video	

TABLE B-I TRACEABILITY MATRIX (Sheet 26 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
10	Environmental Interfaces	N/A	N/A	Environments	Not a requirement.
10.1	Payload Equipment Surface Cleanliness	SSP 57000, SN-C-0005, SSP 50005, Rev. B	3.11.3, All, 13.2.3.2	Environments	
10.1A	Payload Equipment Surface Cleanliness	SSP 57000, SN-C-0005, SSP 50005, Rev. B	3.11.3, All, 13.2.3.2	Environments	
10.1B	Payload Equipment Surface Cleanliness	SSP 57000, SN-C-0005, SSP 50005, Rev. B	3.11.3, All, 13.2.3.2	Environments	
10.2	Illumination Requirements - Lighting Design	NSTS 21000-IDD-MDK, SSP 57000, SSP 50005, Rev. B	5.3, 3.12.3.4, 8.13.3.1.2	Environments	
10.2.1	Work Surface Specularity	SSP 57000	3.12.3.4(A)	Environments	
10.2.2	Supplemental Lighting	SSP 57000	3.12.3.4(B)	Environments	
10.2.3	Direct Light Sources	SSP 57000	3.12.3.4(C)	Environments	
10.2.4	Glovebox Lighting	SSP 57000	3.12.3.4(D)	Environments	
10.2.5	Portable Utility Lighting	SSP 57000	3.12.3.4(E)	Environments	
10.3	Laser Requirements	N/A	N/A	Environments	Not a requirement.
10.3.1	Laser Design and Operation in Compliance wit ANSI Standard Z136.1-1993	NSTS 1700.7B/ISS Addendum, ANSI Z136.1	212.3, All	Environments	
10.3.2	Non-Ionizing Radiation	NSTS 1700.7B/ISS Addendum, SSP 50005, Rev. B	212.2, 5.7.3.2.1	Environments	
10.3.3	Safe Operation	NSTS 1700.7B/ISS Addendum,	212.2	Environments	Also ANSI Z136.1
10.3.4	Accidental Exposures	NSTS 1700.7B/ISS Addendum,	212.2	Environments	Also ANSI Z136.1
10.3.5	Laser and Optical Radiation Monitoring	NSTS 1700.7B/ISS Addendum,	212.2	Environments	Also ANSI Z136.1
10.3.6	Personnel Protection Devices	NSTS 1700.7B/ISS Addendum,	212.2	Environments	Also ANSI Z136.1
10.4	Radiation Requirements	NSTS 1700.7B/ISS Addendum, SSP 30237, KHB 1700.7B	212.1, TBD	Environments	
10.4.1	Payload Contained or Generated Ionizin Radiation	SSP 30243, SSP 30237, SSP 50005, Rev. B	5.7.2.2.2, TBD, 5.7.2	Environments	

TABLE B-I TRACEABILITY MATRIX (Sheet 27 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
10.4.2	Single Event Effect (SEE) Ionizing Radiation	SSP 57000	3.9.3.3	Environments	
10.4.3	Radiation Dose Requirements	N/A	N/A	Environments	Not a requirement.
10.5	Atmosphere Requirements	SSP 57000	3.9.1	Environments	
10.5.1	Oxygen Consumption	SSP 57000	3.9.1.1	Environments	
10.5.2	Chemical Releases	NSTS 1700.7B/ISS Addendum	209.1a, 209.1b	Environments	

TABLE B-I TRACEABILITY MATRIX (Sheet 28 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
11	Laptop Computers and Software	N/A	N/A	Computers/Software	Not a requirement.
11.1	Laptop Computers			Computers/Software	
11.1.1	Payload and General Support Computer	NSTS 21000-IDD-MDK	10.1	Computers/Software	
11.1.1.1	PGSC Electrical Power Characteristics	N/A	N/A	Computers/Software	Not a requirement.
11.1.1.1.1	Payload-Powered PGSC	N/A	N/A	Computers/Software	Not a requirement.
11.1.1.1.2	Orbiter-Powered PGSC	N/A	N/A	Computers/Software	Not a requirement.
11.1.1.2	PGSC Communication/Power Interfaces Cables	N/A	N/A	Computers/Software	Not a requirement.
11.1.1.2.1	RS-232 Communication Cables (Orbiter PGSC)	NSTS 21000-IDD-MDK	10.3.1.1	Computers/Software	NSTS 21000-IDD-486
11.1.1.2.2	RS-422 Communication Cables (Orbiter PGSC)	NSTS 21000-IDD-MDK	10.3.1.2	Computers/Software	NSTS 21000-IDD-486
11.1.1.2.3	Power Cables (Orbiter PGSC)	NSTS 21000-IDD-MDK	10.3.2	Computers/Software	NSTS 21000-IDD-486
11.1.1.3	Software (Orbiter PGSC)	NSTS 21000-IDD-MDK	10.1	Computers/Software	Derived
11.1.2	EXPRESS Rack Laptop	N/A	N/A	Computers/Software	Not a requirement.
11.1.2A	Hardware Description	N/A	N/A	Computers/Software	Not a requirement.
11.1.2B	Hardware Description	N/A	N/A	Computers/Software	Not a requirement.
11.1.2C	Hardware Description	N/A	N/A	Computers/Software	Not a requirement.
11.1.2D	Hardware Description	N/A	N/A	Computers/Software	Not a requirement.
11.1.2E	Hardware Description	N/A	N/A	Computers/Software	Not a requirement.
11.1.2F	Hardware Description	N/A	N/A	Computers/Software	Not a requirement.
11.1.2G	Hardware Description	N/A	N/A	Computers/Software	Not a requirement.
11.1.2H	Hardware Description	N/A	N/A	Computers/Software	Not a requirement.
11.1.2I	Hardware Description	N/A	N/A	Computers/Software	Not a requirement.
11.1.3	ISS Portable Computer System	SSP 52052-IDD-PCS	All	Computers/Software	Requirement under development.
11.2	EXPRESS Rack Software	N/A	N/A	Computers/Software	Not a requirement.
11.2.1	EXPRESS Rack PEHB Interface (Ethernet)	D683-43525-1	3.1.3.1.4, 4.3.1, 4.3.2.3	Computers/Software	
11.2.1A	ISS Payload Ethernet Hub/Gateway Interfaces	N/A	N/A	Computers/Software	Not a requirement.
11.2.1B	Laptop Ethernet Interface	N/A	N/A	Computers/Software	Not a requirement.

TABLE B-I TRACEABILITY MATRIX (Sheet 29 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
11.2.1B(1)	Laptop Ethernet Interface	N/A	N/A	Computers/Software	Not a requirement.
11.2.1B(2)	Laptop Ethernet Interface	N/A	N/A	Computers/Software	Not a requirement.
11.2.1C	Payload Ethernet Interface	D683-43525-1	4.1.7	Computers/Software	
11.2.1C(1)	Payload Ethernet Interface	N/A	N/A	Computers/Software	Not a requirement.
11.2.1C(2)	Payload Ethernet Interface	N/A	N/A	Computers/Software	Not a requirement.
11.2.1C(3)	Payload Ethernet Interface	N/A	N/A	Computers/Software	Not a requirement.
11.2.2	EXPRESS Rack RIC Serial Interface (RS-422)	D683-43525-1	3.1.7.1, 4.1.6	Computers/Software	
11.2.3	Payload Interface Data Elements	N/A	N/A	Computers/Software	Not a requirement.
11.2.3.1	EXPRESS Header	D683-43525-1	4.5.1	Computers/Software	
11.2.3.2	Unique Identifier Numbers	D683-43525-1	N/A	Computers/Software	
11.2.3.3	EXPRESS Telemetry Header	D683-43525-1	4.5.2	Computers/Software	
11.2.3.4	Payload Telemetry Packet	D683-43525-1	4.5.4	Computers/Software	
11.2.3.5	EXPRESS RIC Interface Requests and Responses	D683-43525-1	4.5.6	Computers/Software	
11.2.3.5.1	PEP Bundle Request	D683-43525-1	N/A	Computers/Software	
11.2.3.5.2	PEP Procedure Execution Request	D683-43525-1	N/A	Computers/Software	
11.2.3.5.3	Rack Time Request	D683-43525-1	N/A	Computers/Software	
11.2.3.5.4	Ancillary Data Configuration Control	D683-43525-1	N/A	Computers/Software	
11.2.3.5.5	File Transfer			Computers/Software	
11.2.3.5.5.1	Payload File Transfer			Computers/Software	
11.2.3.5.5.2	EMU File Transfer			Computers/Software	
11.2.3.5.6	Payload Response	D683-43525-1	N/A	Computers/Software	
11.2.3.6	Payload Health and Status Data	D683-43525-1, SSP 57000	4.5.1.8, 3.3.5.1.3, 3.3.5.1.4	Computers/Software	
11.2.3.7	EXPRESS Payload Commanding	D683-43525-1	N/A	Computers/Software	
11.2.4	Laptop CSCI Interfaces	D683-43525-1	3.1.3.1.3, 3.1.3.1.4	Computers/Software	
11.2.4.1	Laptop Data Elements	D683-43525-1	3.1.3.1.3, 3.1.3.1.4	Computers/Software	

TABLE B-I TRACEABILITY MATRIX (Sheet 30 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
11.2.4.2	Payload-Provided Software/Peripherals	TBD	TBD	Computers/Software	Requirement under development.
11.2.4.3	EXPRESS Rack Laptop Display Requirements	SSP 50005, Rev. B	9.4.2.3.2	Computers/Software	Style Guide is TBD.
11.2.4.4	Payload Software Interfaces	TBD	TBD	Computers/Software	
11.2.4.4A	Laptop Communications	D683-43525-1	TBD	Computers/Software	
11.2.4.4B	Software Updating Process for Laptop	D683-43525-1	TBD	Computers/Software	
11.2.4.4C	Payload Application to EXPRESS CSCI	D683-43525-1	TBD	Computers/Software	
11.2.4.5	File Maintenance	TBD	TBD	Computers/Software	Requirement under development.
11.3	Software Safety Requirements for Payloads	NSTS 1700.7B/ISS Addendum	201.1(E)	Computers/Software	

TABLE B-I TRACEABILITY MATRIX (Sheet 31 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
12	Human Factors Interface Requirements	N/A	N/A	Human Factors	Not a requirement.
12.1	Portable Item Handles/Gras Areas/Temporary Stowage Restraints	N/A	N/A	Human Factors	Not a requirement.
12.1.1	Provide Handles and Restraints	SSP 50005, Rev. B SSP 57000	11.6.3.1, 3.12.6.4.1	Human Factors	
12.1.2	Handle Location	SSP 50005, Rev. B SSP 57000	11.6.3.2, 3.12.6.4.3	Human Factors	
12.1.3	Handle Dimensions	SSP 50005, Rev. B SSP 57000	11.6.3.4, 3.12.6.4.4	Human Factors	
12.1.4	Handle Clearance	SSP 57000	3.12.6.4.2	Human Factors	
12.1.5	Non-Fixed Handles Design Requirements	N/A	N/A	Human Factors	Not a requirement.
12.1.5A	Non-Fixed Handles Design Requirements	SSP 57000	3.12.6.4.5	Human Factors	
12.1.5B	Non-Fixed Handles Design Requirements	SSP 57000	3.12.6.4.5	Human Factors	
12.1.5C	Non-Fixed Handles Design Requirements	SSP 57000	3.12.6.4.5	Human Factors	
12.1.6	Tether Points	SSP 50005, Rev. B	TBD	Human Factors	Derived
12.1.7	Captive Parts	Derived (NSTS 1700.7B), NSTS 21000-IDD-MDK	222.4, 3.4.2.5.2	Structures/Loads	
12.1.8	Temporary Stowage/Placement	SSP 50005, Rev. B	TBD	Human Factors	Derived, velcro usage. Requirements under development.
12.2	Strength Requirements	SSP 57000	3.12.1	Human Factors	Not a requirement.
12.2A	Strength Requirements	SSP 57000	3.12.1(A)	Human Factors	Not a requirement
12.2A(1)	Grip Strength	SSP 57000	3.12.1(A.1)	Human Factors	
12.2A(2)	Linear Forces	SSP 57000	3.12.1(A.2)	Human Factors	
12.2A(3)	Torques	SSP 57000	3.12.1(A.3)	Human Factors	
12.2B	Strength Requirements	SSP 57000	3.12.1(B)	Human Factors	
12.3	Body Envelope and Reach Accessibility	SSP 57000	3.12.2	Human Factors	Not a requirement.
12.3.1	Operational Volume	SSP 57000	3.12.2.1	Human Factors	
12.3.2	Accessibility	N/A	N/A	Human Factors	Not a requirement.
12.3.2.A	Accessibility	SSP 57000	3.12.2.2(A)	Human Factors	
12.3.2.B	Accessibility	SSP 57000	3.12.2.2(B)	Human Factors	

TABLE B-I TRACEABILITY MATRIX (Sheet 32 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
12.3.3	Full Size Range Accommodation	SSP 57000	3.12.2.3	Human Factors	
12.4	Payload Hardware Mounting	N/A	N/A	Human Factors	Not a requirement.
12.4.1	Equipment Mounting	SSP 57000	3.12.4.2.1	Human Factors	
12.4.2	Drawers and Hinged Panels	SSP 57000	3.12.4.2.2	Human Factors	
12.4.3	Alignment	SSP 57000	3.12.4.2.5	Human Factors	
12.4.4	Slide-Out Stops	SSP 57000	3.12.4.2.6	Human Factors	
12.4.5	Push-Pull Force	SSP 57000	3.12.4.2.7	Human Factors	
12.4.6	Access	SSP 57000	3.12.4.2.8	Human Factors	
12.4.6.1	Covers	SSP 57000	3.12.4.2.8.1	Human Factors	
12.4.6.1A	Covers	SSP 57000	3.12.4.2.8.1	Human Factors	
12.4.6.1B	Covers	SSP 57000	3.12.4.2.8.1	Human Factors	
12.4.6.1C	Covers	SSP 57000	3.12.4.2.8.1	Human Factors	
12.4.6.2	Self-Supporting Covers	SSP 57000	3.12.4.2.8.2	Human Factors	
12.5	Identification Labeling	SSP 57000	3.12.7	Human Factors	
12.5.1	Color	SSP 57000 SSP 50008	3.12.8 3.2.7	Human Factors	
12.5.2	Fluid Connector Pressure/Flow Indicators	JSC 25607	All	Human Factors	Derived
12.5.3	Coding	N/A	N/A	Human Factors	Not a requirement.
12.5.3A	Coding	SSP 57000	3.12.4.3.12	Human Factors	
12.5.3B	Coding	SSP 57000	3.12.4.3.12	Human Factors	
12.5.4	Pin Identification	SSP 57000	3.12.4.3.13	Human Factors	
12.6	Controls and Displays	N/A	N/A	Human Factors	Not a requirement.
12.6.1	Controls Spacing Design Requirements	SSP 57000	3.12.5.1	Human Factors	
12.6.2	Accidental Actuation	N/A	N/A	Human Factors	Not a requirement.
12.6.2.1	Protective Methods	SSP 50005, Rev. B; SSP 57000	9.3.3, 3.12.5.2.1	Human Factors	
12.6.2.1A	Protective Methods	SSP 50005, Rev. B, SSP 57000	9.3.3, 3.12.5.2.1(A)	Human Factors	
12.6.2.1B	Protective Methods	SSP 50005, Rev. B, SSP 57000	9.3.3, 3.12.5.2.1(B)	Human Factors	

TABLE B-1 TRACEABILITY MATRIX (Sheet 33 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
12.6.2.1C	Protective Methods	SSP 50005, Rev. B, SSP 57000	9.3.3, 3.12.5.2.1(C)	Human Factors	
12.6.2.1D	Protective Methods	SSP 50005, Rev. B, SSP 57000	9.3.3, 3.12.5.2.1(D)	Human Factors	
12.6.2.1E	Protective Methods	SSP 50005, Rev. B, SSP 57000	9.3.3, 3.12.5.2.1(E)	Human Factors	
12.6.2.1F	Protective Methods	SSP 50005, Rev. B, SSP 57000	9.3.3, 3.12.5.2.1(F)	Human Factors	
12.6.2.1G	Protective Methods	SSP 50005, Rev. B, SSP 57000	9.3.3, 3.12.5.2.1(G)	Human Factors	
12.6.2.2	Noninterference	SSP 57000	3.12.5.2.2	Human Factors	
12.6.2.3	Dead-Man Controls	SSP 57000	3.12.5.2.3	Human Factors	
12.6.2.4	Barrier Guards	SSP 57000	3.12.5.2.4	Human Factors	
12.6.2.5	Recessed Switch Protection	SSP 57000	3.12.5.2.5	Human Factors	
12.6.2.6	Position Indication	SSP 57000	3.12.5.2.7	Human Factors	
12.6.2.7	Hidden Controls	SSP 57000	3.12.5.2.8	Human Factors	
12.6.2.8	Hand Controllers	SSP 57000	3.12.5.2.9	Human Factors	
12.6.3	Valve Controls	N/A	N/A	Human Factors	Not a requirement.
12.6.3A	Valve Controls	SSP 57000	3.12.5.3(A)	Human Factors	
12.6.3B	Valve Controls	SSP 57000	3.12.5.3(B)	Human Factors	
12.6.3C	Valve Controls	SSP 57000	3.12.5.3(C)	Human Factors	
12.6.3D	Valve Controls	SSP 57000	3.12.5.3(D)	Human Factors	
12.6.3E	Valve Controls	SSP 57000	3.12.5.3(E)	Human Factors	
12.6.4	Toggle Switches	SSP 57000	3.12.5.4	Human Factors	
12.6.5	Stowage and Equipment Drawers/Trays	N/A	N/A	Human Factors	Not a requirement.
12.6.5A	Stowage and Equipment Drawers/Trays	SSP 57000	3.12.6.2(A)	Human Factors	
12.6.5B	Stowage and Equipment Drawers/Trays	SSP 57000	3.12.6.2(B)	Human Factors	
12.6.6	Audio Devices (Displays)	N/A	N/A	Human Factors	Not a requirement.
12.6.6A	Audio Devices (Displays)	SSP 50005, Rev. B, SSP 57000	9.4.3.3, 3.12.9.10(A)	Human Factors	
12.6.6B	Audio Devices (Displays)	SSP 50005, Rev. B, SSP 57000	9.4.3.3, 3.12.9.10(B)	Human Factors	

TABLE B-I TRACEABILITY MATRIX (Sheet 34 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
12.6.6C	Audio Devices (Displays)	SSP 50005, Rev. B, SSP 57000	9.4.3.3, 3.12.9.10(C)	Human Factors	
12.7	Electrical Connector Design - General	SSP 50005, Rev. B, SSP 57000	11.10.3.2, 3.12.4.3	Human Factors	Not a requirement.
12.7.1	Mismatched	SSP 50005, Rev. B, SSP 57000	6.4.3.7, 3.12.9.1.1	Human Factors	
12.7.2	Connector Protection	SSP 50005, Rev. B, SSP 57000	6.4.3.7, 3.12.4.1.3.8	Human Factors	
12.7.3	Arc Containmen	SSP 50005, Rev. B SSP 57000	11.10.3.2, 3.12.4.3.7	Human Factors	
12.7.4	Connector Arrangement	N/A	N/A	Human Factors	Not a requirement.
12.7.4A	Connector Arrangement	SSP 50005, Rev. B, SSP 57000	11.10.3.2, 3.12.4.3.6(A)	Human Factors	
12.7.4B	Connector Arrangement	SSP 50005, Rev. B, SSP 57000	11.10.3.2, 3.12.4.3.6(B)	Human Factors	
12.7.5	One-Handed Operation	SSP 57000	3.12.4.3.1	Human Factors	
12.7.6	Accessibility	N/A	N/A	Human Factors	Not a requirement.
12.7.6A	Mate/Demate	SSP 57000	3.12.4.3.2(A)	Human Factors	
12.7.6A(1)	Mate/Demate - Nominal Operations	SSP 57000	3.12.4.3.2(A)	Human Factors	
12.7.6A(2)	Mate/Demate - Maintenance Operations	SSP 57000	3.12.4.3.2(A)	Human Factors	
12.7.6B	Accessibility Without Damage	SSP 57000	3.12.4.3.2(B)	Human Factors	
12.7.7	Ease of Disconnect	SSP 57000	3.12.4.3.3	Human Factors	Not a requirement.
12.7.7A	Ease of Disconnect	SSP 57000	3.12.4.3.3(A)	Human Factors	
12.7.7B	Ease of Disconnect	SSP 57000	3.12.4.3.3(B)	Human Factors	
12.7.8	Self-Locking	SSP 57000	3.12.4.3.5	Human Factors	
12.7.9	Connector Shape	SSP 57000	3.12.4.3.9	Human Factors	
12.7.10	Fluid and Gas Line Connectors	SSP 57000	3.12.4.3.10	Human Factors	
12.7.11	Fluid and Gas Line Connectors Mating	SSP 57000	3.12.9.1.1	Human Factors	
12.7.12	Alignment Marks or Guide Pins	SSP 57000	3.12.4.3.11	Human Factors	
12.7.13	Orientation	SSP 57000	3.12.4.3.14	Human Factors	

TABLE B-I TRACEABILITY MATRIX (Sheet 35 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
12.8	Hose/Cable Restraints	N/A	N/A	Human Factors	Not a requirement.
12.9	Habitability/Housekeepin	N/A	N/A	Human Factors	Not a requirement.
12.9.1	Closures or Covers	SSP 57000	3.12.3.1.1	Human Factors	
12.9.2	Built-In Control	N/A	N/A	Human Factors	Not a requirement.
12.9.2A	Built-In Control	SSP 57000	3.12.3.1.2(A)	Human Factors	
12.9.2B	Built-In Control	SSP 57000	3.12.3.1.2(B)	Human Factors	
12.9.3	One-Handed Operation	SSP 57000	3.12.3.1.5	Human Factors	
12.10	Waste Management			Human Factors	Deleted
12.11	Mechanical Energy devices	N/A	N/A	Human Factors	Not a requirement. **TBD#24**
12.12	Fasteners	NSTS 1700.7/ISS Addendum	200.2 and 208	Human Factors	
12.12.1	Non-Threaded Fasteners			Human Factors	
12.12.2	Mounting Bolt/Fastener Spacing			Human Factors	
12.12.3	Multiple Fasteners			Human Factors	
12.12.4	Captive Fasteners			Human Factors	
12.12.5	Quick Release Fasteners			Human Factors	
12.12.5A	Quick Release Fasteners			Human Factors	
12.12.5B	Quick Release Fasteners			Human Factors	
12.12.6	Threaded Fasteners			Human Factors	
12.12.7	Over Center Latches			Human Factors	
12.12.7A	Over Center Latches			Human Factors	
12.12.7B	Over Center Latches			Human Factors	
12.12.7C	Over Center Latches			Human Factors	
12.12.8	Winghead Fasteners			Human Factors	
12.12.9	Fastener Head Type			Human Factors	
12.12.9A	Fastener Head Type			Human Factors	
12.12.9B	Fastener Head Type			Human Factors	
12.12.9C	Fastener Head Type			Human Factors	
12.12.10	One-Handed Actuation			Human Factors	
12.12.11	Accessibility			Human Factors	Deleted
12.12.12	Access Holes			Human Factors	
12.13	Payloa In-Flight Operations and Maintenance Tools	N/A	N/A	Human Factors	Not a requirement.

TABLE B-I TRACEABILITY MATRIX (Sheet 36 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
13	Materials and Parts Interface Requirements	N/A	N/A	Materials	Not a requirement.
13.1	Materials and Processes Use an Selection	NSTS 1700.7B/ISS Addendum, MSFC-HDBK-527/JSC 09694	208.3, and 209, All	Materials	
13.1.1	Acceptance Criteria for Stress Corrosion Cracking (SCC)	MSFC-SPEC-522, NSTS 1700.7B/ISS Addendum	All, 208.3 and 209	Materials	
13.1.2	Hazardous Materials and Compatibility	NSTS 1700.7B/ISS Addendum	209	Materials	
13.1.3	Test and Acceptance Criteria for Flammability	NASA-STD-6001, NSTS 1700.7B/ISS Addendum, NSTS 22648	All, 209, All	Materials	ISPR coated graphit epoxy must be cared for.
13.1.4	Test and Acceptance Criteria for Toxic Offgassing (Toxicity)	NSTS 1700.7B/ISS Addendum, NASA-STD-6001, MSFC-HDBK-527/JSC 09694	209, All, All	Materials	
13.2	Galvanic Corrosion	MIL-STD-889, MSFC-SPEC-250	All, 3.6.2	Materials	
13.3	Fungus-Resistant Materials	SSP 30233	4.2.10	Materials	
13.4	Materials and Parts Certification and Traceability	NSTS 8071.1, NSTS 1700.7B/ ISS Addendum	All, 208.3, 209	Materials	

TABLE B-I TRACEABILITY MATRIX (Sheet 37 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
14	Fire Protection	NSTS 1700.7B/ISS Addendum, SSP 57000, NSTS 22648	220.10, 3.10, All	Fire Detection/Suppression	Derived
14.1	Fire Event Prevention Requirements	NSTS 1700.7B/ISS Addendum	220.10	Fire Detection/Suppression	Derived
14.1.1	Flammability Requirements	NSTS 1700.7B/ISS Addendum, NASA-STD-6001, NSTS 22648	209.2, All, All	Fire Detection/Suppression	Derived
14.1.2	Oxygen	N/A	N/A	Fire Detection/Suppression	Not a requirement.
14.1.2A	Oxygen	NSTS 1700.7B/ISS Addendum	209.1(A)	Fire Detection/Suppression	Derived
14.1.2B	Oxygen	NSTS 1700.7B/ISS Addendum	209.1(A)	Fire Detection/Suppression	Derived
14.1.2C	Oxygen	NSTS 1700.7B/ISS Addendum	209.1(A)	Fire Detection/Suppression	Derived
14.1.3	Electrical Systems	NSTS 1700.7B/ISS Addendum, NSTS 21000-IDD-MDK	7.2.1.4	Fire Detection/Suppression	Derived
14.1.4	Payload Use of Battery Backup Power	NSTS 1700.7B/ISS Addendum, SSP 57000, NSTS 22648	220.10, 3.10, All	Fire Detection/Suppression	Derived
14.1.4A	Payload Use of Battery Backup Power	NSTS 1700.7B/ISS Addendum, SSP 57000, NSTS 22648	220.10, 3.10, All	Fire Detection/Suppression	Derived
14.1.4B	Payload Use of Battery Backup Power	NSTS 1700.7B/ISS Addendum, SSP 57000, NSTS 22648	220.10, 3.10, All	Fire Detection/Suppression	Derived
14.2	Payload Data Monitoring	NSTS 1700.7B/ISS Addendum, SSP 57000	220.10, 3.3.5.1.3, 3.3.5.1.4	Fire Detection/Suppression	Derived
14.2A	Payload Data Monitoring	NSTS 1700.7B/ISS Addendum, SSP 57000	220.10(B), 3.3.5.1.3, 3.3.5.1.4	Fire Detection/Suppression	Derived
14.2B	Payload Data Monitoring	NSTS 1700.7B/ISS Addendum, SSP 57000	220.10(B), 3.3.5.1.3, 3.3.5.1.4	Fire Detection/Suppression	Derived
14.2C	Payload Data Monitoring	NSTS 1700.7B/ISS Addendum, SSP 57000	220.10(B), 3.3.5.1.3, 3.3.5.1.4	Fire Detection/Suppression	Derived

TABLE B-I TRACEABILITY MATRIX (Sheet 38 of 38)

IDD Paragraph No.	Paragraph Title	Document Traceability	Paragraph No.	Discipline or Subject in IDD	Remarks
14.2C(1)	Payload Data Monitoring	NSTS 1700.7B/ISS Addendum, SSP 57000	220.10(B), 3.3.5.1.3, 3.3.5.1.4	Fire Detection/Suppression	Derived
14.2C(2)	Payload Data Monitoring	NSTS 1700.7B/ISS Addendum, SSP 57000	220.10(B), 3.3.5.1.3, 3.3.5.1.4	Fire Detection/Suppression	Derived
14.2C(3)	Payload Data Monitoring	NSTS 1700.7B/ISS Addendum, SSP 57000	220.10(B), 3.3.5.1.3, 3.3.5.1.4	Fire Detection/Suppression	Derived
14.2.1	Fire Event Location Indicator	N/A	N/A	Fire Detection/Suppression	Not a requirement.
14.2.1A	Fire Event Location Indicator	NSTS 1700.7B/ISS Addendum	220.10	Fire Detection/Suppression	Derived
14.2.1B	Fire Event Location Indicator	NSTS 1700.7B/ISS Addendum	220.10	Fire Detection/Suppression	Derived
14.3	PFE Access Port Requirements	N/A	N/A	Fire Detection/Suppression	Not a requirement.
14.3A	PFE Access Port Requirements	NSTS 1700.7B/ISS Addendum	220.10(C)	Fire Detection/Suppression	Derived
14.3B	PFE Access Port Requirements	NSTS 1700.7B/ISS Addendum	220.10(C)	Fire Detection/Suppression	
14.3C	PFE Access Port Requirements	NSTS 1700.7B/ISS Addendum	220.10(C)	Fire Detection/Suppression	
14.3D	PFE Access Port Requirements	NSTS 1700.7B/ISS Addendum, SSP 30262:010	220.10(C), All	Fire Detection/Suppression	
14.3E	PFE Access Port Requirements	NSTS 1700.7B/ISS Addendum	220.10(C)	Fire Detection/Suppression	Derived
14.3F	PFE Access Port Requirements			Fire Detection/Suppression	
14.3G	PFE Access Port Requirements			Fire Detection/Suppression	
14.3H	PFE Access Port Requirements			Fire Detection/Suppression	
14.3.1	PFE Characteristics	SSP 30262:010	All	Fire Detection/Suppression	
14.3.2	PFE Access Port Dimensions	SSP 50006/JSC 27260	6.6.3	Fire Detection/Suppression	
14.3.3	PFE Access	SSP 57000	3.10.3.2	Fire Detection/Suppression	
14.3.4	PFE Quantity	SSP 57000		Fire Detection/Suppression	Derived
14.3.5	PFE Closeouts	NSTS 1700.7B/ISS Addendum	220.10(C)	Fire Detection/Suppression	Derived
14.4	Fire Suppressant Distribution	SSP 57000	3.10.6.3	Fire Detection/Suppression	Derived

APPENDIX C

EXPRESS RACK PAYLOADS IDD
TBD LOG

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TABLE C-1 EXPRESS RACK PAYLOADS IDD TBD LOG (Sheet 1 of 2)

TBD NO.	TBD DESCRIPTION	DATA REQUIRED TO CLOSE TBD	DATA SOURCE/OWNER	REMARKS
TBD-01	The allocation of on-orbit crew time for a “standard” EXPRESS Rack payload is under review.	Identify a value to be used for on-orbit crew time allocation.	ISS Program/OZ2 Page: 1-4 Para: 1.3 Table: N/A Figure: N/A	
TBD-02	The provisions for late access and early removal for “standard” EXPRESS Rack payloads are under review.	Determine whether or not late access an early removal will be available as a “standard” service offered to all EXPRESS Rack payloads.	ISS Program/OZ3 Page: 1-4 Para: 1.3 Table: N/A Figure: N/A	
TBD-03	Closed.	Closed.		
TBD-04	Closed.	Closed.		
TBD-05	Closed.	Closed.		
TBD-06	Closed.	Closed.		
TBD-07	Closed.	Closed.		
TBD-08	Closed.	Closed.		
TBD-09	Closed.	Closed.		
TBD-10	Closed.	Closed.		
TBD-11	Closed.	Closed.		
TBD-12	Closed.	Closed.		Reference **TBD-38**
TBD-13	Closed.	Closed.		Reference **TBD-38**
TBD-14	Closed.	Closed.		Reference **TBD-38**
TBD-15	Closed.	Closed.		
TBD-16	Closed.	Closed.		
TBD-17	Closed.	Closed.		
TBD-18	Closed.	Closed.		
TBD-19	The volume to be used in calculations for acceptable SMAC levels for the ISS has not been defined.	The ISS Program must establish th volume to be used by payload developers i calculation for SMAC Levels for materials.	ISS Program/OZ3 Page: 5-25 Para.: 5.4.7.1 Table: 5-X (Note 4) Figure: N/A	This definition is required not only for EXPRESS Rack Payload developers but also for Facility developers. Free volume of the ISS or each portion of the ISS (i.e., Node, U.S. Lab, PMA, etc.) is required.

TABLE C-1 EXPRESS RACK PAYLOADS IDD TBD LOG (Sheet 2 of 2)

TBD NO.	TBD DESCRIPTION	DATA REQUIRED TO CLOSE TBD	DATA SOURCE/OWNER	REMARKS
TBD-20	Closed.	Closed.		
TBD-21	Closed.	Closed.		
TBD-22	Closed.	Closed.		
TBD-23	Closed.	Closed.		
TBD-24	Closed.	Closed.		
TBD-25	Closed.	Closed.		
TBD-26	Closed.	Closed.		
TBD-27	Closed.	Closed.		
TBD-28	Closed.	Closed.		
TBD-29	Closed.	Closed.		
TBD-30	Closed.			
TBD-31	Closed.	Closed.		
TBD-32	Closed.	Closed.		
TBD-33	Closed.	Closed.		
TBD-34	Closed.	Closed.		
TBD-35	Closed.	Closed.		
TBD-36	Closed.	Closed.		
TBD-37	Definition of the available cleaning materials (i.e., wipes, fluids, etc.) availabl to PDs on orbit must be defined.	Provide list of ISS approved cleaning materials for PDs to use on-orbit.	ISS Program/OZ3 Page: 10-1 Para.: 10.1 Table: N/A Figure: N/A	Change initiated by PCB on 5/27/98.
TBD-38	Define th microgravity requirements for th EXPRESS-Rack payloads.	The MRPO group with th microgravity working group must define these levels at the rack interface. Then the ERO will define the levels at the subrack payload level.	ISS Program 1024 and MRPO Page: Para.: 4.10 Table: N/A Figure N/A	

APPENDIX D

ICD TEMPLATE FOR EXPRESS RACK PAYLOADS

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EXpedite the PRocessing o Experiments to Space Station (EXPRESS) Rack Interface Control Document for {Payload}

International Space Station Program

XX/XX/XX

Revision X

National Aeronautics and Space Administration
International Space Station Program
Johnson Space Center
Houston, Texas
Contract No. NAS8-50000 (DR SE47)

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INTERNATIONAL SPACE STATION

EXPEDITE THE PROCESSING OF EXPERIMENTS
TO SPACE STATION (EXPRESS) RACK
INTERFACE CONTROL DOCUMENT FOR {PAYLOAD ACRONYM}

DR SE47
(SSP 53XXX-ICD)
REVISION

{DATE}

Boeing Defense & Space Group
Missiles & Space Division
(a division of The Boeing Company)
Huntsville, Alabama

	SIGNATURE	ORGN	DATE
PREPARED BY:	EPIM	TBE	
CHECKED BY	D. Jett	TBE	
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DQA:	M. Mathis	TBE	
QA:	Not Applicable	TBE	
SUPERVISED BY:	J. Miller	AR0T	
APPROVED BY:	C. Bailey	AU0T	

INTERNATIONAL SPACE STATION PROGRAM

**EXPRESS RACK
INTERFACE CONTROL DOCUMENT
FOR
{SUB-RACK PAYLOAD NAME}**

{DATE}

PAYLOAD ACRONYM: {PAYLOAD ACRONYM}

PAYLOAD NAME: {Payload Name}

PAYLOAD DEVELOPER: {Payload Developer}

Approved by:	________________	NASA/MSFC/FD31
	EXPRESS ENGINEERING INTEGRATION LEAD SYSTEMS ENGINEER	ORGN
	________________	________
	SIGNATURE	DATE
Approved by:	________________	________
	PAYLOAD DEVELOPER REPRESENTATIVE	ORGN
	________________	________
	SIGNATURE	DATE
Prepared by:	________________	EXPRESS RACK EI
	EXPRESS PAYLOAD INTEGRATION MANAGER	ORGN
	________________	________
	SIGNATURE	DATE

FOREWORD

INTERNATIONAL SPACE STATION PROGRAM

EXPRESS RACK
INTERFACE CONTROL DOCUMENT FOR {PAYLOAD ACRONYM}

This document defines and controls the design of interfaces between the EXPRESS Rack and the {Payload Acronym} payload. The interfaces are defined by direct reference to the corresponding sections and subsections of the EXPRESS Rack Payload Interface Definition Document, SSP 52000-IDD-ERP.

DOC. NO.: SSP 52000-ICD-ERP, Issue C, CR for ICD Template

DOCUMENT RELEASE RECORD (DRR)

RELEASES (& UPDATES)	Update this document by: ACTIVE PAGES	PAGES CHANGED	CCBD NUMBER	AUTHORIZATIONS (& REMARKS)
Initial Release, 7/24/00	i thru ii D-1 thru D-48		SU3-04-0107	ECR FD31-00-34 Initial Release to Issue A of the EXPRESS Rack Interface Definition Document (IDD) for Flight 6A.
Update, 8/2/00	i thru ii D-1 thru D-48	D-27 D-28	SU3-04-0119	ECR FD31-0[illegible] Incorporate[illegible] [illegible]018-003[illegible]rical [illegible]ower Ada[illegible]able[illegible]
Update, 8/2/00	i thru ii D-1 thru D-48	D-29 D-31	SU3-0[illegible]	[illegible]CR FD31[illegible] [illegible]corporate[illegible]SP [illegible]018-005[illegible] Adapter [illegible]able.
Update, 10/11/00	i thru ii[illegible] D-1[illegible]-48	[illegible]	[illegible]U3[illegible]	[illegible]CR FD3[illegible] [illegible] [illegible]1[illegible]ceptions to [illegible] Use of Battery [illegible]ackup Requirements.
Up[illegible] 10[illegible]	i[illegible] [illegible]	[illegible]3	[illegible]U3[illegible]195	ECR FD31-00-102 Applicability updates to include Issue B of the Express Rack IDD.
Up[illegible] 1[illegible]	[illegible]u ii [illegible]1 thru D-48	D-10 D-11	PCB approved 1/31/01 as part of EXPRESS Rack PIRN 57201-NA 0027A	Incorporate PIRN SSP 52018-012, Exceedance to Structural (Acoustic) Requirements.
Update, 2/2/01	i thru ii D-1 thru D-48	D-37 D-38 D-42	PCB approved 2/2/01	Incorporate PIRN SSP 52018-006A, Exceptions to Human Factors.
Update, 2/16/01	i thru ii D-1 thru D-48	i ii	N/A	Added Document Release Record page
Update, 2/26/01	i thru ii D-1 thru D-48	D-25 D-26	SU3-04-0254	ECR FD31-01-19 Incorporate PIRN SSP 52018-0048, Backplate Bonding Surface Exception.

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

LIST OF FIGURES

LIST OF TABLES

TABLE OF CONTENTS (CONTINUED)

APPENDIX D.1, INTRODUCTION

D.1.1 PURPOSE

This ICD defines and controls the design of interfaces between the EXPRESS Rack and the “Payload Name” payload (also included are interfaces to the Orbiter). The interfaces are defined by direct reference to the corresponding sections and subsections of the EXPRESS Rack Payload Interface Definition Document (IDD), SSP 52000-IDD-ERP. In the event of conflict between the IDD and this ICD, this ICD will take precedence.

D.1.2 HARDWARE DESCRIPTION

The hardware items covered by this ICD are shown in Table D-I. The payload configuration is shown pictorially in Figure D-1.

D.1.3 RELATIONSHIP TO EXPRESS INTEGRATION AGREEMENT (EIA)

The EIA represents the payload to International Space Station Program (ISSP) agreement on the responsibilities and tasks which directly relate to the integration of the payload into the ISSP, and includes the definition of tasks which the ISSP considers optional/special services. This ICD provides specific design data and defines the engineering analyses applicable to the EXPRESS Rack/payload interfaces and optional/special services identified in the EIA. EIA Payload Data Library (PDL) Data Sets are established for the Payload Developer (PD) to provide the detail data necessary for the International Space Station (ISS) elements to configure flight and ground systems and implement other integration functions as provided in the EIA.

TABLE D-I PAYLOAD HARDWARE IDENTIFICATION

NOMENCLATURE	PART NUMBER	SERIAL NUMBER	COMMENTS/ NOTES
See Note 1	See Note 2	See Note 2	See Note 3

NOTES:

1. List name/nomenclature of each hardware item covered by this ICD and planned to be verified for flight (includes stowage).
2. List corresponding part numbers and serial numbers for each item listed in nomenclature column.
3. List flight effectivity for each item in the first two columns as well as any other information pertinent to the hardware item(s) to be flown.
4. Interfaces to the Orbiter (i.e., shuttle middeck) are covered here also.

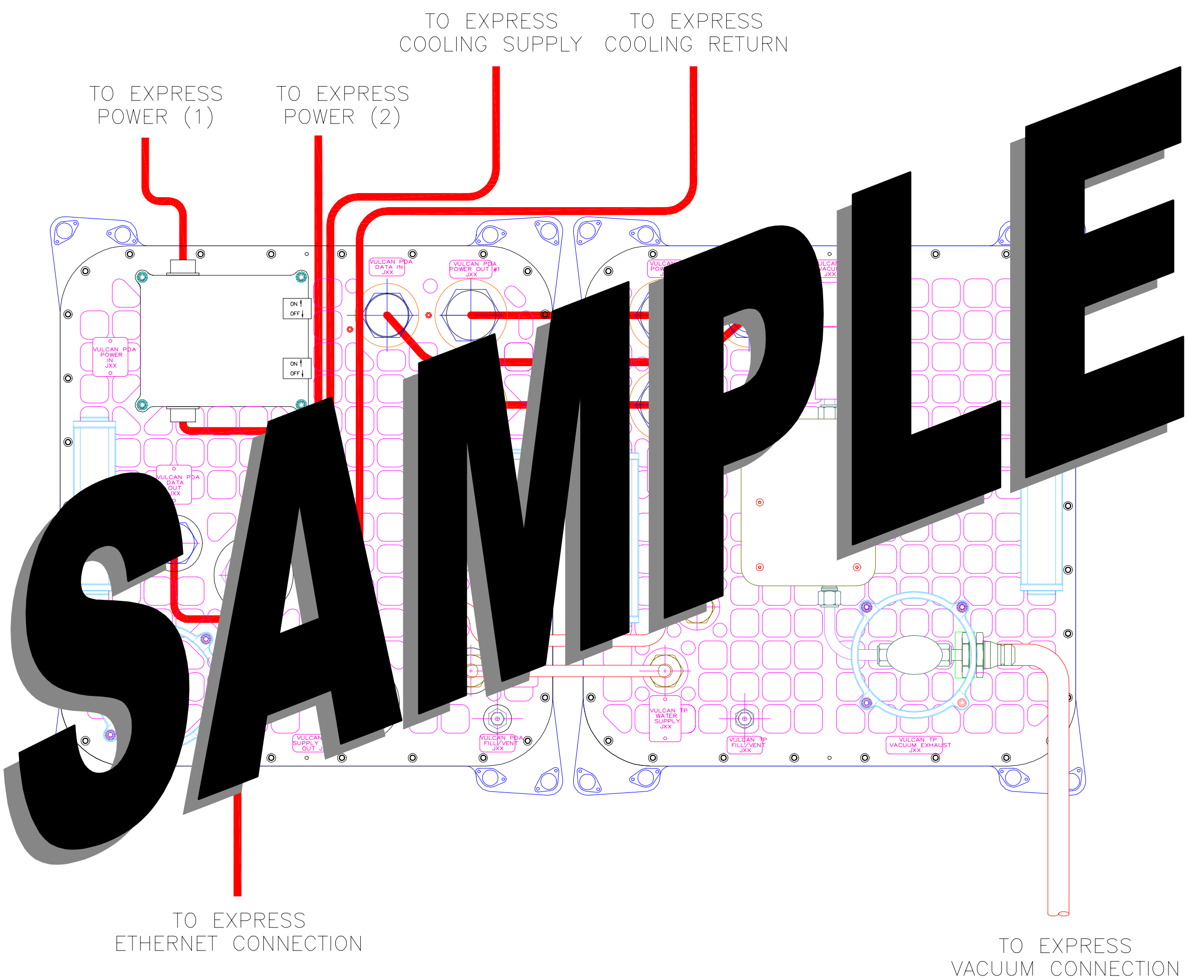

FIGURE D-1 PAYLOAD CONFIGURATION
(includes Ascent, On-Orbit, Descent as applicable)

APPENDIX D.2, DOCUMENTATION

D.2.1 DOCUMENTATION HIERARCHY

D.2.1.1 EXPRESS Rack/Payload ICD

The unique ICD shall be used for the following functions:

A. Defines and controls all interfaces which shall be provided by the ISS and EXPRESS Rack for use by payloads.

B. Defines and controls all constraints which shall be observed by all members of the payload community in using the interfaces so defined.

C. Establishes commonality with respect to analytical approaches, analytical models, technical data and definitions for integrated analysis by all interfacing parties.

Note: Interfaces to the Orbiter (i.e., Shuttle Middeck) are covered here also.

D.2.1.2 Organization of EXPRESS Rack/Payload ICD

The unique ICD has the same numbers and headings for each section and subsection as the EXPRESS Rack Payload IDD, except for Sections 1.0 and 2.0, which are unique. Each paragraph of the unique ICD (following Section 2) is dispositioned with one of the following:

NAR Not a requirement (e.g., section heading, no shall statement)

A Applicable to this ICD.

N/A Not applicable to this ICD.

A-N Applicable with note.

E An exceedance, deviation, or waiver is taken to the EXPRESS Rack payload IDD paragraph. The subsection 15 shall be approved by special consideration or analysis and approved by an Multi-Use Payload Group (MUPG) Change Control Board (CCB) Directive. Exceedance, deviation, or waiver shall use less than the total EXPRESS Rack capability.

Note: If paragraph is "Not Applicable," the following subparagraphs are also "Not Applicable"; therefore, the subparagraphs shall not be listed or dispositioned in the unique ICD.

D.2.2 APPLICABLE DOCUMENTS

Applicable documents contained in SSP 52000-IDD-ERP, as well as the following documents, form a part of this unique ICD to the extent specified herein. In the event of conflict between this unique ICD and any other documents involved herein, the contents of this ICD shall govern.

D.2.3 REFERENCE DOCUMENTS

SSP 52000-EIA-ERP	EXPRESS Integration Agreement
SSP 52000-IDD-ERP	EXPRESS Rack Payload Interface Definition Document
SSP 52000-PVP-ERP and -ERP/IA	Payload Verification Plan for EXPRESS Rack Payloads and Instruction Annex
SSP 52000-PAH-ERP	Payload Accommodation Handbook for EXPRESS Rack Payloads

The PD is responsible for keeping up with current approved changes to the EXPRESS Rack Payloads IDD. The PD will be expected to either meet the new requirements, or give satisfactory explanation to the ISS via the Preliminary/Proposed Interface Revision Notice (PIRN) process that the current experiment design is acceptable.

D.2.4 ICD WAIVERS, DEVIATIONS, AND EXCEEDANCES

Unique ICD agreements with the payload are based on ISSP (including EXPRESS Rack) and Space Station Program (SSP) allowed payload services and provisions and are identified in this document. All Orbiter/SSP and ISSP/EXPRESS Rack design-to requirements for payloads are controlled at the Payloads Office PCB.

This unique payload ICD does not require SSP Orbiter Project or ISSP approval if it remains within the Orbiter vehicle and EXPRESS Rack interface design parameters.

Any exceedance, deviation, or waiver to the EXPRESS Rack Payload IDD shall be documented in this Payload-Unique ICD, Section 15, and evaluated to assure the state condition is controlled in a manner to guarantee acceptable conditions to eliminate any added risk to the vehicle (Shuttle, ISS, EXPRESS Rack) or crew.

DEFINITIONS

EXCEPTION: The general term used to identify any payload-proposed departure from specified requirements or interfaces. An exception is further classified as an exceedance, deviation, or waiver per the descriptions provided below.

EXCEEDANCE: An exceedance is a condition that does not comply with a stated IDD requirement which is identified prior to baselining the Payload-Unique ICD. It exceeds the defined payload limits, but when combined with the remaining payload complement, the EXPRESS Rack limits are not exceeded, or it does not impact the performance of the remaining payload complement, and it does not impact vehicle subsystems performance. The exception can be shown to be acceptable within the framework of the standard element level analysis cycle without any unique analysis or controls.

An exceedance can be approved by the MUPG and documented in the Payload-Unique ICD.

For example, one of the requirements is that the delta-T on the Moderate Temperature Loop (MTL) should be at least 35 ºF. If "Payload X" wishes to have a delta-T of 32 ºF, this would be classified as an exceedance. It does not exceed vehicle limits or affect safety; it only influences the efficiency of the use of the MTL.

DEVIATION: A deviation is a non-compliance to an IDD requirement, which is identified prior to baselining the Payload-Unique ICD. It is different from an exceedance in that the defined exception exceeds EXPRESS Rack limits. Additional analysis outside the scope of the standard element analysis cycle or unique operational guidelines or constraints may be needed to approve the exception. Deviations must be approved by the MUPG and the Payload Technical Review (PTR).

For example, one of the requirements is that the maximum return temperature of the MTL should be 120 ºF. If "Payload Y" wishes to have a return temperature of 123 ºF and their ICD has not been baselined, this would be classified as a Deviation. The vehicle is designed to accommodate return temperatures of 120 ºF or less, and special analysis must be done to determine if the vehicle can accommodate this or if operational constraints will be required.

WAIVER: A waiver is a condition found in noncompliance to an IDD requirement or to the baselined Payload-Unique ICD, which is identified after baselining the Payload-Unique ICD. Typically this will occur as a result of the final as-built hardware verification program. It may require additional analysis outside of the scope of the standard element analysis cycle or unique operational guidelines or constraints to approve the exception. Waivers must be approved by the MUPG and PTR.

For example, one of the requirements is that the continuous acoustic noise must not exceed NC 40. “Payload Z” has already baselined their ICD, and recent testing of the flight hardware shows that their continuous noise level is NC 45. Additional evaluation will be required to determine if this can be accepted, and it may result in operational constraints.

D.3 MECHANICAL INTERFACES

The EXPRESS Rack Payload IDD, SSP 52000-IDD-ERP, paragraphs are disposition as follows:

TABLE D-II ICD MECHANICAL INTERFACE REQUIREMENTS (Sheet 1 of 4)

DISPOSITION	IDD RQMT NO.	REQUIREMENT TITLE
NAR	3.1	Geometric Relationships
NAR	3.1.1	Crew Module (CM) Coordinate System
NAR	3.1.2	International Standard Payload Rack (ISPR) Coordinate Systems (Limited Effectivity)
NAR	3.1.3	Payload (PL) Coordinate System
NAR	3.2	Dimensions and Tolerances
NAR	3.3	Mechanical Interfaces
NAR	3.3.1	Middeck Locations
NAR	3.3.1.1	Avionics Bay Locations
	3.3.1.2	Middeck Payload Provisions
NAR	3.3.2	ISS Locations
NAR	3.3.2A	ISS Locations
NAR	3.3.2B	ISS Locations
NAR	3.3.2C	ISS Locations
NAR	3.4	Mechanical Payload Provisions
NAR	3.4.1	EXPRESS Mounting Plates
	3.4.1.1	8/2 EXPRESS Rack Mounting Plate
	3.4.1.2	EXPRESS Transportation Rack Mounting Plate
	3.4.2	Standard Modular Locker
NAR	3.4.2.1	Standard Stowage Trays
	3.4.2.2	Modified Locker Access Door
NAR	3.4.2.3	Payload Zero-G Requirements
	3.4.2.3A	Payload Zero-G Requirements
	3.4.2.3B	Payload Zero-G Requirements
	3.4.2.3C	Payload Zero-G Requirements
	3.4.2.4	Isolation Material Properties
	3.4.2.5	ISS-Supplied Lockers
NAR	3.4.2.6	PD-Supplied Locker Requirements

TABLE D-II ICD MECHANICAL INTERFACE REQUIREMENTS (Sheet 2 of 4)

DISPOSITION	IDD RQMT NO.	REQUIREMENT TITLE
	3.4.2.6A	PD-Supplied Locker Requirements/Latches
NAR	3.4.2.6B	PD-Supplied Locker Requirements/Latches
	3.4.3	Mounting Panels
	3.4.3.1	Single Adapter Plate
	3.4.3.2	Double Adapter Plate
	3.4.3.3	Payload Mounting Panel
	3.4.3.4	Vented Payload Mounting Panel
	3.4.3.4.1	Orbiter Inlet/Outlet Locations for Ducted Air-Cooled Payloads
	3.4.3.4.1.1	Orbiter Inlet/Outlet Locations for Single Payload Accommodations
	3.4.3.4.1.2	Orbiter Inlet/Outlet Locations for Double Payload Accommodations
	3.4.3.5	Mounting Access
NAR	3.4.3.5.1	On-Orbit Separation Interface Requirements
	3.4.3.5.1A	On-Orbit Separation Interface Requirements
	3.4.3.5.1B	On-Orbit Separation Interface Requirements
	3.4.3.5.1C	On-Orbit Separation Interface Requirements
	3.4.3.5.2	Closeout Cover Access
NAR	3.4.3.6	Payload Attachment Point Provisions
NAR	3.4.3.6.1	Orbiter/Middeck
	3.4.3.6.1.1	Attachment Hardware – Payloads Without Planned On-Orbit Transfers
	3.4.3.6.1.2	Attachment Hardware – Payloads With Planned On-Orbit Transfers
	3.4.3.6.2	EXPRESS Rack Backplate
	3.4.3.6.2.1	Interface Attachment Capabilities
	3.4.3.6.2.2	Maximum Dimensions Envelope
	3.4.3.6.3	Captive Fasteners
	3.4.3.6.4	On-Orbit Removal of Fasteners
NAR	3.4.4	ISIS Drawer Payload Provisions
NAR	3.4.4.1	Stowage ISIS Drawers
	3.4.4.1A	Stowage ISIS Drawers
	3.4.4.1B	Stowage ISIS Drawers
	3.4.4.1C	Stowage ISIS Drawers
	3.4.4.1D	Stowage ISIS Drawers

TABLE D-II ICD MECHANICAL INTERFACE REQUIREMENTS (Sheet 3 of 4)

DISPOSITION	IDD RQMT NO.	REQUIREMENT TITLE
	3.4.4.1E	Stowage ISIS Drawers
NAR	3.4.4.2	Powered ISIS Drawers
	3.4.4.2A	Powered ISIS Drawers
	3.4.4.2B	Powered ISIS Drawers
	3.4.4.2C	Powered ISIS Drawers
	3.4.4.2D	Powered ISIS Drawers
	3.4.4.2E	Powered ISIS Drawers
	3.4.4.2F	Powered ISIS Drawers
	3.4.4.2G	Powered ISIS Drawers
NAR	3.4.4.3	ISIS Drawer Replacement
	3.4.5	Securing of Threaded Fasteners
	3.4.5.1	Fracture-Critical Threaded Fasteners
NAR	3.4.5.2	Redundant Threaded Fasteners Locking Requirements
	3.4.5.2A	Redundant Threaded Fasteners Locking Requirements
	3.4.5.2B	Redundant Threaded Fasteners Locking Requirements
	3.4.5.2C	Redundant Threaded Fasteners Locking Requirements
	3.4.5.2D	Redundant Threaded Fasteners Locking Requirements
	3.4.5.2E	Redundant Threaded Fasteners Locking Requirements
	3.4.5.2F	Redundant Threaded Fasteners Locking Requirements
NAR	3.5	Ground Support Equipment (GSE)
NAR	3.5.1	Ground Handling
	3.5.2	MPLM Late/Early Access Requirements
NAR	3.5.2.1	MPLM Late Access Envelope (Kennedy Space Flight Center (KSC))
	3.5.2.1A	MPLM Late Access Envelope (Kennedy Space Flight Center (KSC))
	3.5.2.1B	MPLM Late Access Envelope (Kennedy Space Flight Center (KSC))
	3.5.2.1C	MPLM Late Access Envelope (Kennedy Space Flight Center (KSC))
NAR	3.5.2.2	MPLM Early Access Envelopes (KSC and Dryden Flight Research Center (DFRC))
	3.5.2.2A	MPLM Early Access Envelopes KSC and Dryden Flight Research Center (DFRC))
	3.5.2.2B	MPLM Early Access Envelopes KSC and Dryden Flight Research Center (DFRC))
NAR	3.6	Envelope Requirements

TABLE D-II ICD MECHANICAL INTERFACE REQUIREMENTS (Sheet 4 of 4)

DISPOSITION	IDD RQMT NO.	REQUIREMENT TITLE
NAR	3.6.1	Payload Static Envelopes
	3.6.1A	Payload Static Envelopes
	3.6.1B	Payload Static Envelopes
	3.6.1C	Payload Static Envelopes
NAR	3.6.2	On-Orbit Payload Protrusions
	3.6.2A	On-Orbit Payload Protrusions
	3.6.2B	On-Orbit Payload Protrusions
	3.6.2.1	Front Face Protrusions (Permanent)
NAR	3.6.2.2	On-Orbit Semi-Permanent Protrusions
	3.6.2.2A	On-Orbit Semi-Permanent Protrusions
	3.6.2.2B	On-Orbit Semi-Permanent Protrusions
NAR	3.6.2.3	On-Orbit Temporary Protrusions
	3.6.2.3A	On-Orbit Temporary Protrusions
	3.6.2.3B	On-Orbit Temporary Protrusions
	3.6.2.4	On-Orbit Momentary Protrusions
	3.6.2.5	On-Orbit Protrusions for Keep-Alive Payloads
	3.6.3	Sharp Edges and Corners
	3.6.3.1	Protective Covers/Shields
	3.6.3.2	Holes
	3.6.3.3	Screws/Bolts Ends
	3.6.3.4	Burrs
	3.6.3.5	Latches
	3.6.3.6	Levers, Cranks, Hooks, and Controls
	3.6.3.7	Safety/Lockwire
	3.6.3.8	Securing Pins
	3.6.4	Pressure Relief Device Location
NAR	3.7	Mechanical Interfaces for Crew Restraints and Mobility Aids
NAR	3.7.1	Hardware Definition
	3.7.2	Interface Compatibility
	3.8	IVA Transfer Pathway
	3.9	Orbiter Overhead Window Interface Requirements

NAR = Not a requirement.

Figure to be supplied by Payload prior to Baseline

FIGURE D-1 PAYLOAD CONFIGURATION
(includes Ascent, On-Orbit, Descent as applicable)

D.4 STRUCTURAL INTERFACES

The EXPRESS Rack Payload IDD, SSP 52000-IDD-ERP, paragraphs are dispositioned as follows:

TABLE D-III ICD STRUCTURAL INTERFACE REQUIREMENTS (Sheet 1 of 2)

DISPOSITION	IDD RQMT NO.	REQUIREMENT TITLE
NAR	4.1	Operational Loads
	4.1.1	Component Frequency
	4.1.2	Payload Low Frequency Launch and Landing Loads
NAR	4.2	Emergency Landing Loads Factors
	4.2.1	Middeck
NAR	4.3	Random Vibration
	4.3.1	Random Vibration - MPLM
	4.3.2	Random Vibration - Middeck
NAR	4.4	EXPRESS Rack MDL Location Interface Loads
	4.4.1	Single MDL Location Interface Loads
	4.4.2	Double MDL Location Interface Loads
	4.4.3	Quad MDL Location Interface Loads
NAR	4.5	On-Orbit Loads
	4.5.1	Crew-Induced Loading
	4.5.2	On-Orbit Low Frequency Loads
NAR	4.6	EXPRESS Rack Payload Structural Design
	4.6.1	Structural Design
	4.6.2	Fracture Control
NAR	4.7	Acoustics
	4.7.1	Lift-Off and Ascent Acoustics
NAR	4.7.2	Payload-Generated Acoustic Noise
NAR	4.7.2.1	Acoustic Noise Definitions
NAR	4.7.2.1.1	Significant Noise Source
NAR	4.7.2.1.2	Continuous Noise Source
NAR	4.7.2.1.3	Intermittent Noise Source
NAR	4.7.2.1.4	Acoustic Reference
	4.7.2.2	Acoustic Noise Limits
	4.7.2.2.1	Continuous Noise Limits
	4.7.2.2.2	Intermittent Noise Limits

TABLE D-III ICD STRUCTURAL INTERFACE REQUIREMENTS (Sheet 2 of 2)

DISPOSITION	IDD RQMT NO.	REQUIREMENT TITLE
	4.7.2.2.3	Continuous Noise Sources with Intermittent Noise Features
NAR	4.7.2.2.3A	Continuous Noise Sources with Intermittent Noise Features
NAR	4.7.2.2.3B	Continuous Noise Sources with Intermittent Noise Features
NAR	4.7.2.2.3C	Continuous Noise Sources with Intermittent Noise Features
	4.7.2.3	Sound Power Readings on Payloads
	4.7.2.4	Acoustic Test Plan for Payloads
NAR	4.8	Depressurization/Repressurization Requirements
	4.8.1	USL, APM, CAM, and JEM Maximum Depressurization/ Repressurization Rates
	4.8.2	MPLM Maximum Depressurization/Repressurization Rate
	4.8.3	Middeck Maximum Depressurization/Repressurization Rates
	4.8.4	Portable Fire Extinguisher (PFE) Discharge Rate
NAR	4.9	Ground Handling Environments
	4.9.1	Ground Handling Load Factors
	4.9.2	Ground Handling Shock Criteria
NAR	4.10	Microgravity Disturbances
	4.10.1	Quiescent Period Payload-Induced Quasi-Steady Accelerations
NAR	4.10.2	Quiescent Period Payload-Induced Transient Accelerations
NAR	4.10.3	Quiescent Period Payload-Induced On-Orbit Vibration
	4.10.3A	Quiescent Period Payload-Induced On-Orbit Vibration
	4.10.3B	Quiescent Period Payload-Induced On-Orbit Vibration
NAR	4.10.4	Angular Momentum Limits
	4.10.4A	Angular Momentum Limits
	4.10.4B	Angular Momentum Limits
	4.10.4C	Angular Momentum Limits
	4.10.4D	Angular Momentum Limits
	4.10.4E	Angular Momentum Limits
	4.10.4F	Angular Momentum Limits
	4.10.4G	Angular Momentum Limits
	4.10.4.1	Limit Disturbance Induced ISS Attitude Rate
	4.10.4.2	Limit Disturbance Induced Control Moment Gyroscope (CMG) Momentum Usage
	4.11	Constraints for ARIS EXPRESS Rack Activity

NAR = Not a requirement.

D.5 THERMAL/FLUIDS INTERFACES

The EXPRESS Rack Payload IDD, SSP 52000-IDD-ERP, paragraphs are dispositioned as follows:

TABLE D-IV ICD THERMAL INTERFACE REQUIREMENTS (Sheet 1 of 4)

DISPOSITION	IDD RQMT NO.	REQUIREMENT TITLE
NAR	5.1	General Requirements
NAR	5.1.1	External Surface Touch Temperature
	5.1.1A	External Surface Touch Temperature
	5.1.1B	External Surface Touch Temperature
	5.1.1C	External Surface Touch Temperature
	5.1.2	Condensation Prevention
	5.1.2.1	Condensation Prevention (Refrigerators/Freezers)
	5.1.3	Loss of Cooling
	5.1.4	Pressure Relief/Vent Valve Sizing
	5.1.5	Pressurized Gas Systems
	5.2	ISS Laboratory (Cabin) Environmental Conditions
NAR	5.3	Payload Element Cooling
NAR	5.3.1	Payload Heat Dissipation
NAR	5.3.1.1	Passive Cooling
	5.3.1.1.1	Payload Front Surface Temperature
	5.3.1.1.2	Cabin Air Heat Leak
	5.3.1.1.3	Convective Heat Transfer Coefficient
	5.3.1.2	Active Cabin Air Cooling/Heating Interface
	5.3.1.2.1	Particulate(s) and Filters/Debris Traps
NAR	5.3.1.3	Avionics Air Cooling
NAR	5.3.1.3.1	Physical Interface
NAR	5.3.1.3.1.1	MDLs
NAR	5.3.1.3.1.2	ISIS Drawers
	5.3.1.3.1.3	Fans
	5.3.1.3.1.4	Sealing Surfaces
	5.3.1.3.1.5	Maximum Air Leakage Across Payload Mounting Interface
	5.3.1.3.2	Air Supply Temperature
NAR	5.3.1.3.3	Air Flow Rate
	5.3.1.3.3.1	MDLs

TABLE D-IV ICD THERMAL INTERFACE REQUIREMENTS (Sheet 2 of 4)

DISPOSITION	IDD RQMT NO.	REQUIREMENT TITLE
	5.3.1.3.3.2	ISIS Drawers
	5.3.1.3.4	Air Return Temperature
	5.3.1.3.5	Payload Inlet Debris Traps
NAR	5.3.1.3.6	Maximum Allowable Heat Dissipation
	5.3.1.3.7	Payload Limitations on Heat Conducted to Structure
	5.3.1.4	Middeck Ducted Air Cooling
NAR	5.3.1.4.1	Bay 1 Ducted Air Cooling Capability
NAR	5.3.1.4.1.1	Bay 1 Standard Air Flow Capability
NAR	5.3.1.4.1.2	Bay 2 Ducted Air Cooling Capability
NAR	5.3.1.4.1.2.1	Bay 2 Standard Air Flow Capability
NAR	5.3.1.4.2	Bay 3A Ducted Air Cooling Capability
NAR	5.3.1.4.2.1	Bay 3A Standard Air Flow Capability
	5.3.1.4.3	Payload Limitations on Heat Conducted to Structure
	5.3.1.4.4	Payload Outlet Air Pressure Requirement
NAR	5.3.1.4.5	Ducted Payload Air Pressure Requirement
NAR	5.3.1.4.5.1	Single Size MDL Payload Air Cooling Interface
NAR	5.3.1.4.5.2	Double Size MDL Payload Air Cooling Interface
	5.3.1.4.6	Cabin and Avionics Bay Air Mixing Limitations
	5.3.1.4.7	Ducted Payload Limitations on Heat Convected or Radiated to Cabin Air
	5.3.1.4.8	Maximum Air Leakage Across Payload Mounting Interface Requirement
NAR	5.3.1.5	Water Cooling Interface Requirements
	5.3.1.5.1	Physical Interface
NAR	5.3.1.5.2	Fluid Use
	5.3.1.5.2A	Fluid Use
	5.3.1.5.2B	Fluid Use
	5.3.1.5.2C	Fluid Use
	5.3.1.5.2D	Fluid Use
	5.3.1.5.2E	Fluid Use
	5.3.1.5.3	Water Quantity
	5.3.1.5.4	Thermal Expansion

TABLE D-IV ICD THERMAL INTERFACE REQUIREMENTS (Sheet 3 of 4)

DISPOSITION	IDD RQMT NO.	REQUIREMENT TITLE
NAR	5.3.1.5.4A	Thermal Expansion
NAR	5.3.1.5.4B	Thermal Expansion
NAR	5.3.1.5.4C	Thermal Expansion
	5.3.1.5.5	Water Loop Pressure Drop
	5.3.1.5.6	QD Air Inclusion
	5.3.1.5.7	Leak Rate
	5.3.1.5.8	Water Coolant Flow Rate
	5.3.1.5.9	Water Coolant Supply Temperature
	5.3.1.5.10	Water Coolant Return Temperature
	5.3.1.5.11	Maximum Water Coolant System Pressure
	5.3.2	USL/APM/JEM/Centrifuge Accommodation Module (CAM) Unique Thermal Control Interface Requirements
NAR	5.4	Vacuum Exhaust System/Waste Gas System Interface Requirements (USL, APM, JEM)
	5.4.1	Physical Interface (USL, APM, JEM)
	5.4.2	Input Pressure Limit (USL, APM, JEM)
	5.4.3	Input Temperature Limit (USL, APM, JEM)
	5.4.4	Input Dewpoint Limit (USL, APM, JEM)
	5.4.5	Vacuum Exhaust System (VES)/Waste Gas System (WGS) MDP
	5.4.6	Leak Rate (USL, APM, JEM)
	5.4.7	Acceptable Effluents (USL, APM, JEM)
NAR	5.4.7.1	Acceptable Gases (USL, APM, JEM)
	5.4.7.1A	Acceptable Gases (USL, APM, JEM)
	5.4.7.1B	Acceptable Gases (USL, APM, JEM)
	5.4.7.1C	Acceptable Gases (USL, APM, JEM)
	5.4.7.1D	Acceptable Gases (USL, APM, JEM)
	5.4.7.2	External Contamination Control (USL, APM, JEM)
NAR	5.4.7.3	Incompatible Exhaust Gases (USL, APM, JEM)
	5.4.7.3A	Incompatible Exhaust Gases (USL, APM, JEM)
	5.4.7.3B	Incompatible Exhaust Gases (USL, APM, JEM)
	5.4.8	Utility Control
NAR	5.5	Gaseous Nitrogen (GN_2) Interface Requirements
	5.5.1	Physical Interface
	5.5.2	Utility Control

TABLE D-IV ICD THERMAL INTERFACE REQUIREMENTS (Sheet 4 of 4)

DISPOSITION	IDD RQMT NO.	REQUIREMENT TITLE
	5.5.3	GN_2 System MDP
	5.5.4	Interface Pressure (USL, APM)
	5.5.5	Temperature
	5.5.6	Leak Rate
	5.5.7	GN_2 Characteristics
NAR	5.5.7A	GN_2 Characteristics
NAR	5.5.7B	GN_2 Characteristics
NAR	5.5.7C	GN_2 Characteristics

NAR = Not a requirement.

TABLE D-V PAYLOAD THERMAL INTERFACES

HARDWARE ITEM (See Note 1)	INTERFACE TYPE	QUANTITY OF INTERFACES	CHARACTERISTICS	REMARKS (See Note 2)
	Moderate Temp Water Loop	X	Flow Rate: xxx lbm/hr Heat to Loop: xxxx.x W (max/min) Volume: xxx.xx liters	
	Vacuum Exhaust System Waste Gas System	X	Exhaust Gases and Quantities: Note 3 Venting Frequency: xx times per day/hr/min Venting Duration: xxxx minutes Isolation Methodology: ____	
	GN_2	X	Flow Rate: xxx.xx lbm/hr Quantity: xxx.x lbm	
	Avionics Air (Interface to the ER AAA)	X	Flow Rate: xxxx.x lbm/hr (include P/L Fan(s)) Heat to Loop: xxxx.x W (max/min)	
	Cabin Air	X	Heat Load: xxxx.x W (max/min)	

NOTES:
1. List part number, serial number.
2. Identify flight effectivity.
3. List each gas exhausted and the quantity in volume/pressure/temperature.

D.6 ELECTRICAL POWER INTERFACES

The EXPRESS Rack Payload IDD, SSP 52000-IDD-ERP, paragraphs are dispositioned as follows:

TABLE D-VI ICD ELECTRICAL POWER INTERFACE REQUIREMENTS
(Sheet 1 of 3)

DISPOSITION	IDD RQMT NO.	REQUIREMENT TITLE
NAR	6.1	Electrical Power/Energy
NAR	6.1.1	Baseline Power Allocation
NAR	6.1.2	Shuttle/Middeck Power and Voltage
NAR	6.2	EXPRESS Rack dc Power Characteristics
NAR	6.2.1	28 Vdc Power and Voltage
	6.2.1.1	Voltage Levels
NAR	6.2.1.2	Output Impedance
	6.2.1.3	Reverse Current
	6.2.1.4	Reverse Energy
NAR	6.2.1.5	Soft Start/Stop
NAR	6.2.2	Overload Protection
	6.2.2.1	Overload Protection Device
	6.2.2.1.1	Device Accessibility
	6.2.2.1.2	Location
	6.2.2.1.3	Device Identification
	6.2.2.1.4	Extractor-Type Fuse Holder
NAR	6.2.3	Current Limiting
	6.2.3A	Current Limiting
	6.2.3B	Current Limiting
	6.2.3C	Current Limiting
	6.2.3D	Current Limiting
NAR	6.3	Ripple and Transient Spike (Repetitive) Limits - Shuttle/Middeck
NAR	6.3.1	In-Flight dc Power Bus Ripple at the Interface - Shuttle/Middeck
	6.3.1A	In-Flight dc Power Bus Ripple at the Interface - Shuttle/Middeck
	6.3.1B	In-Flight dc Power Bus Ripple at the Interface - Shuttle/Middeck
	6.3.2	In-Flight dc Power Transient Spikes (Repetitive) - Shuttle/Middeck
	6.3.3	Ground dc Power - Shuttle/Middeck
NAR	6.3.3A	Ground dc Power - Shuttle/Middeck

TABLE D-VI ICD ELECTRICAL POWER INTERFACE REQUIREMENTS
(Sheet 2 of 3)

DISPOSITION	IDD RQMT NO.	REQUIREMENT TITLE
NAR	6.3.3B	Ground dc Power - Shuttle/Middeck
NAR	6.3.3C	Ground dc Power - Shuttle/Middeck
	6.3.4	Ac Power Characteristics - Shuttle/Middeck
	6.4	Ripple and Transient Spikes (Repetitive) Limits - ISS
	6.4.1	Startup Condition Spikes
	6.4.2	Differential Mode PARD (Noise/Ripple)
NAR	6.5	Limitations on EXPRESS Rack Payload Utilization of Electrical Power
NAR	6.5.1	On-Orbit Transfer
NAR	6.5.2	EXPRESS Rack Payload Electrical Safety/Hazards
	6.5.2.1	Batteries
NAR	6.5.2.2	Safety-Critical Circuits
	6.5.2.2A	Safety-Critical Circuits
	6.5.2.2B	Safety-Critical Circuits
	6.5.2.2C	Safety-Critical Circuits
NAR	6.5.2.3	Electrical Hazards
NAR	6.5.2.3A	Electrical Hazards
	6.5.2.3B	Electrical Hazards
	6.5.2.3C	Electrical Hazards
	6.5.2.3D	Electrical Hazards
	6.5.2.3E	Electrical Hazards
	6.5.3	Power Loss
	6.5.3.1	Automatic Starting After Power Loss
	6.5.4	Emergency Operational Modes
	6.5.5	Payload Element Activation/Deactivation and Isolation
NAR	6.6	Electrical Connectors
	6.6.1	Connector Pins/Sockets
	6.6.2	Electrical Connector Mating/Demating (Unpowered)
	6.6.3	Electrical Connector Mating/Demating (Powered)
	6.6.3A	Electrical Connector Mating/Demating (Powered)
	6.6.3B	Electrical Connector Mating/Demating (Powered)
	6.6.3B(1)	Electrical Connector Mating/Demating (Powered)
	6.6.3B(2)	Electrical Connector Mating/Demating (Powered)

TABLE D-VI ICD ELECTRICAL POWER INTERFACE REQUIREMENTS
(Sheet 3 of 3)

DISPOSITION	IDD RQMT NO.	REQUIREMENT TITLE
	6.6.3B(3)	Electrical Connector Mating/Demating (Powered)
	6.6.3B(4)	Electrical Connector Mating/Demating (Powered)
	6.6.4	Electrical Connector Mismating Prevention
	6.6.4A	Electrical Connector Mismating Prevention
	6.6.4B	Electrical Connector Mismating Prevention
	6.6.4C	Electrical Connector Mismating Prevention
	6.6.4D	Electrical Connector Mismating Prevention
	6.6.5	Mechanical Protection
	6.6.6	Current Draw Labeling

NAR = Not a requirement.

TABLE D-VII PAYLOAD ELECTRICAL INTERFACES

ISS AND ORBITER SERVICE BY FLIGHT	HARDWARE ITEM (See Note 2)	QUANTITY OF INTERFACES	VOLTAGE RANGE (See Note 4)	SSPC SETTING (AMPS) (See Note 1)	POWER WATTS		TIME LIMIT ON PEAK POWER (Minutes/Frequency of Occurrence)	CONTINUOUS POWER (Yes/No)	PAYLOAD CHARACTERISTICS (See Note 5)	REMARKS (See Note 3)
					MAX CONT.	PEAK				
Prelaunch:										
Ascent:										
On-orbit:										
Descent:										
Postlanding:										

NOTES:

1. SSPC Setting: Specify 5A, 10A, 15A, or 20A. It must match warning label on payload front panel.
2. List part number, serial number.
3. Identify flight effectivity.
4. List Voltage Range – Middeck – 24 – 32 V/EXPRESS Rack 25.5 – 29.5.
5. Payload Characteristics: Specify whether payload is resistive, constant power, or both. If both, state the percentage of constant power.

D.7 ELECTROMAGNETIC COMPATIBILITY (EMC)

The EXPRESS Rack Payload IDD, SSP 52000-IDD-ERP, paragraphs are dispositioned as follows:

TABLE D-VIII ICD ELECTROMAGNETIC COMPATIBILITY INTERFACE REQUIREMENTS (Sheet 1 of 3)

DISPOSITION	IDD RQMT NO.	REQUIREMENT TITLE
NAR	7.1	Circuit EMC Classifications
NAR	7.2	Shuttle-Produced Interference Environment
	7.2.1	Conducted Interference
	7.2.2	Radiated Interference - Shuttle/Middeck
NAR	7.2.2A	Radiated Interference - Shuttle/Middeck
	7.2.2B	Radiated Interference - Shuttle/Middeck
NAR	7.2.2C	Radiated Interference - Shuttle/Middeck
	7.2.2D	Radiated Interference - Shuttle/Middeck
	7.2.2E	Radiated Interference - Shuttle/Middeck
	7.2.2.1	Shuttle-Produced Wireless Crew Communication System (WCCS) Radiated Electric Fields
NAR	7.3	Electromagnetic Compatibility
	7.3.1	Emission and Susceptibility Limits and Test Methods
	7.3.1.1	Compatibility
NAR	7.3.1.2	Applicability
	7.3.1.3	Conducted Emissions
NAR	7.3.1.3.1	CE01, Conducted Emissions
	7.3.1.3.2	CE01 Limits
NAR	7.3.1.3.3	CE03, Conducted Emissions
	7.3.1.3.4	CE03 Limits
NAR	7.3.1.3.5	CE07, Conducted Emissions
	7.3.1.3.6	CE07 Limits
NAR	7.3.1.4	Conducted Susceptibility
NAR	7.3.1.4.1	CS01, Conducted Susceptibility
	7.3.1.4.2	CS01 Limits
NAR	7.3.1.4.3	CS02, Conducted Susceptibility
	7.3.1.4.4	CS02 Limits
NAR	7.3.1.4.5	CS06, Conducted Susceptibility
	7.3.1.4.6	CS06 Limits

TABLE D-VIII ICD ELECTROMAGNETIC COMPATIBILITY INTERFACE REQUIREMENTS (Sheet 2 of 3)

DISPOSITION	IDD RQMT NO.	REQUIREMENT TITLE
NAR	7.3.1.4.6A	CS06 Limits
NAR	7.3.1.4.6B	CS06 Limits
NAR	7.3.1.5	Radiated Emissions
NAR	7.3.1.5.1	RE02, Radiated Emissions
NAR	7.3.1.5.2	Applicability
	7.3.1.5.3	RE02 Limits
	7.3.1.5.4	Narrowband Electric Field Emissions
NAR	7.3.1.6	Radiated Susceptibility
NAR	7.3.1.6.1	RS02, Radiated Susceptibility
NAR	7.3.1.6.2	Applicability
	7.3.1.6.3	RS02 Limits
NAR	7.3.1.6.3A	RS02 Limits
NAR	7.3.1.6.3B	RS02 Limits
NAR	7.3.1.7	RS03, Radiated Susceptibility
NAR	7.3.1.7.1	Applicability
	7.3.1.7.2	RS03 Limits
NAR	7.3.2	Electrostatic Discharge
	7.3.2.1	ESD Compatibility
	7.3.2.2	ESD Labeling
	7.3.2.3	Corona
	7.3.2.4	Lightning
NAR	7.4	Payload-Produced Interference Environment - Shuttle
NAR	7.4.1	Payload-Produced Conducted Noise - Shuttle
	7.4.1A	Payload-Produced Conducted Noise - Shuttle
	7.4.1B	Payload-Produced Conducted Noise - Shuttle
	7.4.1C	Payload-Produced Conducted Noise - Shuttle
NAR	7.4.2	Payload-Produced Radiated Fields - Shuttle
	7.4.2A	Payload-Produced Radiated Fields - Shuttle
	7.4.2B	Payload-Produced Radiated Fields - Shuttle
	7.4.2C	Payload-Produced Radiated Fields - Shuttle
	7.4.2D	Payload-Produced Radiated Fields - Shuttle

TABLE D-VIII ICD ELECTROMAGNETIC COMPATIBILITY INTERFACE REQUIREMENTS (Sheet 3 of 3)

DISPOSITION	IDD RQMT NO.	REQUIREMENT TITLE
NAR	7.4.3	Magnetic Fields for EXPRESS Rack Payloads in the ISS
	7.4.3.1	Alternating Current (ac) Magnetic Fields for EXPRESS Rack Payloads in the ISS
	7.4.3.2	Direct Current (dc) Magnetic Fields for EXPRESS Rack Payloads in the ISS
NAR	7.5	Avionics Electrical Compatibility - Shuttle and ISS
	7.5.1	Electrical Bonding
	7.5.1A	Fault Current Bond - Class C
	7.5.1B	Shock Hazard - Class H
	7.5.1C	Radio Frequency (RF) Bond - Class R
	7.5.1D	Static Bond - Class S
	7.5.1.1	Electrical Bonding of Payload Hardware
	7.5.1.1.1	Redundant Bond Paths
NAR	7.5.1.2	Electrical Bonding of Payload Structures
NAR	7.5.1.2.1	Payload-to-EXPRESS Rack Main Bond
	7.5.1.2.1.1	Primary Payload Power Connector Bond
	7.5.1.2.1.2	Payload-to-EXPRESS Rack Bond Strap
	7.5.1.2.1.3	Payload-to-EXPRESS Rack Mated Surface Bond
NAR	7.5.1.2.2	Payload-to-EXPRESS Rack and Fluid Line Bonding
NAR	7.5.2	Circuit Reference Symbols
NAR	7.6	Power Circuit Isolation and Grounding
	7.6.1	EXPRESS Rack 28 Vdc Primary Power Bus Isolation
NAR	7.6.2	Dc Power Ground Reference
	7.6.3	Payload Secondary Power Isolation and Grounding
	7.6.4	GSE Isolation and Grounding
NAR	7.7	Signal Isolation and Grounding Requirements
	7.7.1	Ethernet
	7.7.2	RS-422
	7.7.3	SSPCM Analog Grounding
	7.7.4	SSPCM Discrete
	7.7.5	Video
	7.7.6	Shield References

NAR = Not a requirement.

D.8 ELECTRICAL WIRING INTERFACE

The EXPRESS Rack Payload IDD, SSP 52000-IDD-ERP, paragraphs are dispositioned as follows:

TABLE D-IX ICD ELECTRICAL WIRING INTERFACE REQUIREMENTS

DISPOSITION	IDD RQMT NO.	REQUIREMENT TITLE
NAR	8.1	General
NAR	8.1.1	Connector/Pin Interfaces
	8.1.1.1	MDLs/MDL Replacement
	8.1.1.1.1	Previously Flown (Shuttle) MDLs/MDL Replacement
	8.1.1.2	ISIS Drawers
	8.1.2	Approved Connectors for EXPRESS Rack Payload Use
NAR	8.2	Cable Schematics

NAR = Not a requirement

D.9 COMMAND AND DATA HANDLING (C&DH) INTERFACES

The EXPRESS Rack Payload IDD, SSP 52000-IDD-ERP, paragraphs are dispositioned as follows:

TABLE D-X ICD COMMAND AND DATA HANDLING INTERFACE REQUIREMENTS (Sheet 1 of 2)

DISPOSITION	IDD RQMT NO.	REQUIREMENT TITLE
NAR	9.1	RS-422 Communications
	9.1.1	Signal Characteristics
	9.1.2	Telemetry Format
	9.1.3	Request/Command Format
	9.1.4	Processing Requirements
NAR	9.1.5	Connector/Pin Interface
	9.1.5.1	MDLs/MDL Replacements
	9.1.5.2	ISIS Drawers
NAR	9.2	Ethernet Communications
	9.2.1	Signal Characteristics
	9.2.2	Communications Protocol
	9.2.3	Telemetry Format
	9.2.4	Request/Command Format
	9.2.5	Processing Requirements
NAR	9.2.6	Connector/Pin Interface
	9.2.6.1	MDLs/MDL Replacements
	9.2.6.2	ISIS Drawers
NAR	9.2.7	Communications to Laptop
NAR	9.3	Analog Communications
	9.3.1	Signal Characteristics
	9.3.2	Analog Driver Characteristics
NAR	9.3.3	Connector/Pin Interface
	9.3.3.1	MDLs/MDL Replacement
	9.3.3.2	ISIS Drawers
NAR	9.4	Discrete Communications
NAR	9.4.1	Discrete Signal Characteristics
	9.4.1.1	Discrete Output Low Level
	9.4.1.2	Discrete Output High Level

TABLE D-X ICD COMMAND AND DATA HANDLING INTERFACE REQUIREMENTS (Sheet 2 of 2)

DISPOSITION	IDD RQMT NO.	REQUIREMENT TITLE
	9.4.1.3	Discrete Output Maximum Fault Current
	9.4.1.4	Discrete Input Low Level
	9.4.1.5	Discrete Input High Level
	9.4.1.6	Discrete Input Maximum Fault Voltage
	9.4.2	Discrete Driver and Receiver Characteristics
NAR	9.4.3	Connector/Pin Interface
	9.4.3.1	MDLs/MDL Replacement
	9.4.3.2	ISIS Drawers
	9.5	Continuity Discrete Jumper
	9.6	Point-to-Point Communications Bus (PPCB)
	9.7	Video
NAR	9.7.1	Payload Video Characteristics
	9.7.1.1	Input Impedance
	9.7.1.2	Sync Tip
	9.7.1.3	Blanking Level
	9.7.1.4	White Reference
NAR	9.7.2	Deviations to Video Standard
NAR	9.7.2A	Deviations to Video Standard
NAR	9.7.2B	Deviations to Video Standard
NAR	9.7.2C	Deviations to Video Standard
NAR	9.7.2D	Deviations to Video Standard
NAR	9.7.2E	Deviations to Video Standard
	9.7.3	Connector/Pin Interface

NAR = Not a requirement.

D.10 ENVIRONMENTAL INTERFACES

The EXPRESS Rack Payload IDD, SSP 52000-IDD-ERP, paragraphs are dispositioned as follows:

TABLE D-XI ICD ENVIRONMENTAL CONDITIONS INTERFACE REQUIREMENTS

DISPOSITION	IDD RQMT NO.	REQUIREMENT TITLE
NAR	10.1	Payload Equipment Surface Cleanliness
	10.1A	Payload Equipment Surface Cleanliness
	10.1B	Payload Equipment Surface Cleanliness
NAR	10.2	Illumination Requirements - Lighting Design
	10.2.1	Work Surface Specularity
	10.2.2	Supplemental Lighting
	10.2.3	Direct Light Sources
	10.2.4	Glovebox Lighting
	10.2.5	Portable Utility Lighting
NAR	10.3	Laser Requirements
	10.3.1	Laser Design and Operation in Compliance with ANSI Standard Z136.1-1993
	10.3.2	Non-Ionizing Radiation
	10.3.3	Safe Operation
	10.3.4	Accidental Exposures
	10.3.5	Laser and Optical Radiation Monitoring
	10.3.6	Personnel Protection Devices
NAR	10.4	Radiation Requirements
	10.4.1	Payload Contained or Generated Ionizing Radiation
	10.4.2	Single Event Effect (SEE) Ionizing Radiation
NAR	10.4.3	Radiation Dose Requirements
NAR	10.5	Atmosphere Requirements
	10.5.1	Oxygen Consumption
	10.5.2	Chemical Releases

NAR = Not a requirement.

D.11 LAPTOP COMPUTERS AND SOFTWARE

The EXPRESS Rack Payload IDD, SSP 52000-IDD-ERP, paragraphs are dispositioned as follows:

TABLE D-XII ICD COMPUTERS AND SOFTWARE INTERFACE REQUIREMENTS (Sheet 1 of 2)

DISPOSITION	IDD RQMT NO.	REQUIREMENT TITLE
NAR	11.1	Laptop Computers
	11.1.1	Payload and General Support Computer
NAR	11.1.1.1	PGSC Electrical Power Characteristics
NAR	11.1.1.1.1	Payload-Powered PGSC
NAR	11.1.1.1.2	Orbiter-Powered PGSC
NAR	11.1.1.2	PGSC Communication/Power Interfaces Cables
	11.1.1.2.1	RS-232 Communication Cables (Orbiter PGSC)
	11.1.1.2.2	RS-422 Communication Cables (Orbiter PGSC)
	11.1.1.2.3	Power Cables (Orbiter PGSC)
	11.1.1.3	Software (Orbiter PGSC)
NAR	11.1.2	EXPRESS Rack Laptop
	11.1.2A	Hardware Description
	11.1.2B	Hardware Description
	11.1.2B	Hardware Description
	11.1.2C	Hardware Description
	11.1.2D	Hardware Description
	11.1.2E	Hardware Description
	11.1.2F	Hardware Description
	11.1.2G	Hardware Description
	11.1.2H	Hardware Description
	11.1.2I	Hardware Description
	11.1.3	ISS Portable Computer System (PCS)
NAR	11.2	EXPRESS Rack Software
	11.2.1	EXPRESS Rack PEHB Interface (Ethernet)
NAR	11.2.1A	ISS Payload Ethernet Hub/Gateway Interfaces
NAR	11.2.1B	Laptop Ethernet Interface
NAR	11.2.1B(1)	Laptop Ethernet Interface

TABLE D-XII ICD COMPUTERS AND SOFTWARE INTERFACE REQUIREMENTS
(Sheet 2 of 2)

DISPOSITION	IDD RQMT NO.	REQUIREMENT TITLE
NAR	11.2.1B(2)	Laptop Ethernet Interface
NAR	11.2.1C	Payload Ethernet Interface
NAR	11.2.1C(1)	Payload Ethernet Interface
NAR	11.2.1C(2)	Payload Ethernet Interface
NAR	11.2.1C(3)	Payload Ethernet Interface
	11.2.2	EXPRESS Rack RIC Serial Interface (RS-422)
NAR	11.2.3	Payload Interface Data Elements
	11.2.3.1	EXPRESS Header
NAR	11.2.3.2	Unique Identifier Numbers
	11.2.3.3	EXPRESS Telemetry Header
	11.2.3.4	Payload Telemetry Packet
	11.2.3.5	EXPRESS RIC Interface Requests and Responses
NAR	11.2.3.5.1	PEP Bundle Request
NAR	11.2.3.5.2	PEP Procedure Execution Request
NAR	11.2.3.5.3	Rack Time Request
NAR	11.2.3.5.4	Ancillary Data Configuration Control
	11.2.3.5.5	File Transfer
NAR	11.2.3.5.5.1	Payload File Transfer
NAR	11.2.3.5.5.2	EMU File Transfer
NAR	11.2.3.5.6	Payload Response
	11.2.3.6	Payload Health and Status Data
	11.2.3.7	EXPRESS Payload Commanding
	11.2.4	Laptop CSCI Interfaces
NAR	11.2.4.1	Laptop Data Elements
	11.2.4.2	Payload-Provided Software/Peripherals
	11.2.4.3	EXPRESS Rack Laptop Display Requirements
NAR	11.2.4.4	Payload Software Interfaces
	11.2.4.4A	Laptop Communications
NAR	11.2.4.4B	Software Updating Process for Laptop
	11.2.4.4C	Payload Application to EXPRESS CSCI
	11.2.4.5	File Maintenance
	11.3	Software Safety Requirements for Payloads

NAR = Not a requirement.

D.12 HUMAN FACTORS INTERFACE REQUIREMENTS

The EXPRESS Rack Payload IDD, SSP 52000-IDD-ERP, paragraphs are dispositioned as follows:

TABLE D-XIII ICD HUMAN FACTORS INTERFACE REQUIREMENTS (Sheet 1 of 5)

DISPOSITION	IDD RQMT NO.	REQUIREMENT TITLE
NAR	12.1	Portable Item Handles/Grasp Areas/Temporary Stowage Restraints
	12.1.1	Provide Handles and Restraints
	12.1.2	Handle Location
	12.1.3	Handle Dimensions
	12.1.4	Handle Clearance
NAR	12.1.5	Non-Fixed Handles Design Requirements
	12.1.5A	Non-Fixed Handles Design Requirements
	12.1.5B	Non-Fixed Handles Design Requirements
	12.1.5C	Non-Fixed Handles Design Requirements
	12.1.6	Tether Points
	12.1.7	Captive Parts
	12.1.8	Temporary Stowage/Placement
NAR	12.2	Strength Requirements
NAR	12.2A	Strength Requirements
	12.2A(1)	Grip Strength
	12.2A(2)	Linear Forces
	12.2A(3)	Torques
	12.2B	Strength Requirements
NAR	12.3	Body Envelope and Reach Accessibility
	12.3.1	Operational Volume
NAR	12.3.2	Accessibility
TBD-ISS	12.3.2A	Accessibility
	12.3.2B	Accessibility
	12.3.3	Full Size Range Accommodation
NAR	12.4	Payload Hardware Mounting
	12.4.1	Equipment Mounting
	12.4.2	Drawers and Hinged Panels

TABLE D-XIII ICD HUMAN FACTORS INTERFACE REQUIREMENTS (Sheet 2 of 5)

DISPOSITION	IDD RQMT NO.	REQUIREMENT TITLE
	12.4.3	Alignment
	12.4.4	Slide-Out Stops
	12.4.5	Push-Pull Force
	12.4.6	Access
NAR	12.4.6.1	Covers
	12.4.6.1A	Covers
	12.4.6.1B	Covers
	12.4.6.1C	Covers
	12.4.6.2	Self-Supporting Covers
	12.5	Identification Labeling
	12.5.1	Color
	12.5.2	Fluid Connector Pressure/Flow Indicators
NAR	12.5.3	Coding
	12.5.3A	Coding
	12.5.3B	Coding
	12.5.4	Pin Identification
NAR	12.6	Controls and Displays
	12.6.1	Controls Spacing Design Requirements
NAR	12.6.2	Accidental Actuation
	12.6.2.1	Protective Methods
NAR	12.6.2.1A	Protective Methods
	12.6.2.1B	Protective Methods
	12.6.2.1C	Protective Methods
	12.6.2.1D	Protective Methods
NAR	12.6.2.1E	Protective Methods
NAR	12.6.2.1F	Protective Methods
NAR	12.6.2.1G	Protective Methods
	12.6.2.2	Noninterference
NAR	12.6.2.3	Dead-Man Controls
	12.6.2.4	Barrier Guards
	12.6.2.5	Recessed Switch Protection
	12.6.2.6	Position Indication

TABLE D-XIII ICD HUMAN FACTORS INTERFACE REQUIREMENTS (Sheet 3 of 5)

DISPOSITION	IDD RQMT NO.	REQUIREMENT TITLE
	12.6.2.7	Hidden Controls
	12.6.2.8	Hand Controllers
NAR	12.6.3	Valve Controls
	12.6.3A	Valve Controls (Low-Torque Valves)
	12.6.3B	Valve Controls (Intermediate-Torque Valves)
	12.6.3C	Valve Controls (High-Torque Valves)
	12.6.3D	Valve Controls (Handle Dimensions)
	12.6.3E	Valve Controls (Rotary Valve Controls)
	12.6.4	Toggle Switches
NAR	12.6.5	Stowage and Equipment Drawers/Trays
	12.6.5A	Stowage and Equipment Drawers/Trays
	12.6.5B	Stowage and Equipment Drawers/Trays
NAR	12.6.6	Audio Devices (Displays)
	12.6.6A	Audio Devices (Displays)
	12.6.6B	Audio Devices (Displays)
	12.6.6C	Audio Devices (Displays)
NAR	12.7	Electrical Connector Design - General
	12.7.1	Mismatched
	12.7.2	Connector Protection
	12.7.3	Arc Containment
NAR	12.7.4	Connector Arrangement
	12.7.4A	Connector Arrangement
	12.7.4B	Connector Arrangement
	12.7.5	One-Handed Operation
NAR	12.7.6	Accessibility
NAR	12.7.6A	Mate/Demate
	12.7.6A(1)	Mate/Demate - Nominal Operations
	12.7.6A(2)	Mate/Demate - Maintenance Operations
	12.7.6B	Accessibility Without Damage
NAR	12.7.7	Ease of Disconnect
	12.7.7A	Ease of Disconnect

TABLE D-XIII ICD HUMAN FACTORS INTERFACE REQUIREMENTS (Sheet 4 of 5)

DISPOSITION	IDD RQMT NO.	REQUIREMENT TITLE
	12.7.7B	Ease of Disconnect
	12.7.8	Self-Locking
	12.7.9	Connector Shape
	12.7.10	Fluid and Gas Line Connectors
	12.7.11	Fluid and Gas Line Connectors Mating
	12.7.12	Alignment Marks or Guide Pins
	12.7.13	Orientation
NAR	12.8	Hose/Cable Restraints
NAR	12.9	Habitability/Housekeeping
	12.9.1	Closures or Covers
NAR	12.9.2	Built-In Control
	12.9.2A	Built-In Control
	12.9.2B	Built-In Control
	12.9.3	One-Handed Operation
	12.10	Deleted
	12.11	Mechanical Energy Devices
NAR	12.12	Fasteners
	12.12.1	Non-Threaded Fasteners
	12.12.2	Mounting Bolt/Fastener Spacing
	12.12.3	Multiple Fasteners
	12.12.4	Captive Fasteners
NAR	12.12.5	Quick Release Fasteners
	12.12.5A	Quick Release Fasteners
	12.12.5B	Quick Release Fasteners
	12.12.6	Threaded Fasteners
NAR	12.12.7	Over Center Latches
	12.12.7A	Over Center Latches
	12.12.7B	Over Center Latches
	12.12.7C	Over Center Latches
	12.12.8	Winghead Fasteners
NAR	12.12.9	Fastener Head Type
	12.12.9A	Fastener Head Type

TABLE D-XIII ICD HUMAN FACTORS INTERFACE REQUIREMENTS (Sheet 5 of 5)

DISPOSITION	IDD RQMT NO.	REQUIREMENT TITLE
	12.12.9B	Fastener Head Type
	12.12.9C	Fastener Head Type
	12.12.10	One-Handed Actuation
	12.12.11	Deleted
	12.12.12	Access Holes
	12.13	Payload In-Flight Operations and Maintenance Tools

NAR = Not a requirement.

D.13 MATERIALS AND PARTS INTERFACE REQUIREMENTS

The EXPRESS Rack Payload IDD, SSP 52000-IDD-ERP, paragraphs are dispositioned as follows:

TABLE D-XIV ICD MATERIALS AND PARTS INTERFACE REQUIREMENTS

DISPOSITION	IDD RQMT NO.	REQUIREMENT TITLE
	13.1	Materials and Processes Use and Selection
	13.1.1	Acceptance Criteria for Stress Corrosion Cracking (SCC)
	13.1.2	Hazardous Materials and Compatibility
	13.1.3	Test and Acceptance Criteria for Flammability
	13.1.4	Test and Acceptance Criteria for Toxic Offgassing (Toxicity)
	13.2	Galvanic Corrosion
	13.3	Fungus-Resistant Material
	13.4	Materials and Parts Certification and Traceability

NAR = Not a requirement.

D.14 FIRE PROTECTION

The EXPRESS Rack Payload IDD, SSP 52000-IDD-ERP, paragraphs are dispositioned as follows:

TABLE D-XV ICD FIRE PROTECTION INTERFACE REQUIREMENTS (Sheet 1 of 2)

DISPOSITION	IDD RQMT NO.	REQUIREMENT TITLE
	14.1	Fire Event Prevention Requirements
	14.1.1	Flammability Requirements
NAR	14.1.2	Oxygen
	14.1.2A	Oxygen
	14.1.2B	Oxygen
	14.1.2C	Oxygen
NAR	14.1.3	Electrical Systems
	14.1.4	Payload Use of Battery Backup Power
NAR	14.1.4A	Payload Use of Battery Backup Power
NAR	14.1.4B	Payload Use of Battery Backup Power
	14.2	Payload Data Monitoring
	14.2A	Payload Data Monitoring
	14.2B	Payload Data Monitoring
	14.2C	Payload Data Monitoring
NAR	14.2C(1)	Payload Data Monitoring
NAR	14.2C(2)	Payload Data Monitoring
NAR	14.2C(3)	Payload Data Monitoring
NAR	14.2.1	Fire Event Location Indicator
NAR	14.2.1A	Fire Event Location Indicator
NAR	14.2.1B	Fire Event Location Indicator
	14.3	PFE Access Port Requirements
	14.3A	PFE Access Port Requirements
NAR	14.3B	PFE Access Port Requirements
	14.3C	PFE Access Port Requirements
	14.3D	PFE Access Port Requirements
	14.3E	PFE Access Port Requirements
	14.3F	PFE Access Port Requirements
	14.3G	PFE Access Port Requirements
	14.3H	PFE Access Port Requirements

TABLE D-XV ICD FIRE PROTECTION INTERFACE REQUIREMENTS (Sheet 2 of 2)

DISPOSITION	IDD RQMT NO.	REQUIREMENT TITLE
	14.3.1	PFE Characteristics
	14.3.2	PFE Access Port Dimensions
	14.3.3	PFE Access
	14.3.4	PFE Quantity
	14.3.5	PFE Closeouts
	14.4	Fire Suppressant Distribution

NAR = Not a requirement.

D.15 EXCEPTIONS

Exceptions, unique/nonstandard interface requirements and notes from the ICD are listed in this section in Table D-XVI below. Any flight effectivity for these exceptions as well as the MUPG/PCB directive are to be entered in the last column of this table.

TABLE D-XVI ICD EXCEPTIONS, UNIQUE/NONSTANDARD INTERFACE REQUIREMENTS, AND NOTES

HARDWARE ITEM NOMENCLATURE	PART NUMBER	SERIAL NUMBER	IDD REQUIREMENT NO.	EXCEPTION OR UNIQUE INTERFACE DESCRIPTION OR NOTES

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APPENDIX E

INSTRUCTIONS FOR LABELS AND DECALS

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TABLE OF CONTENTS

LIST OF FIGURES

TABLE OF CONTENTS (CONTINUED)

LIST OF TABLES

APPENDIX E, INSTRUCTIONS FOR LABELS AND DECALS

E.1 INTRODUCTION

The ISS Payload Label Approval Team (IPLAT) reviews and approves labels for all payload equipment that the crew will interface with during nominal operations, planned maintenance, and contingency operations. IPLAT does not approve operations nomenclature, procedures or displays. The Payload Operations Data File (PODF) group reviews and approves operations nomenclature and procedures. The Payload Display Review Panel (PDRP) reviews and approves all software displays. IPLAT, PODF and PDRP consult with one another regarding label issues that have implications for procedures and displays.

Appendix E provides the instructions for the approval of payload labels. The development of labels will be a joint process requiring the cooperative efforts of the IPLAT and the PD. The process for developing labels, from the beginning to the delivery of flight certified labels which have been approved by IPLAT, is documented in Figure E-1.

To understand the priorities of the instructions, the following definitions need to be applied throughout Appendix E.

Statements with “must” will be used for instructions which are required to be met for IPLAT to provide approval.

Statements with “should” will be used for instructions which are incorporated into the label unless adequate justification is provided to IPLAT to warrant exempting the label instruction.

The term “label” used throughout these instructions refers to any one of the following:

A. Silk-screened labels: Markings that are silk-screened, with ink, onto hardware.

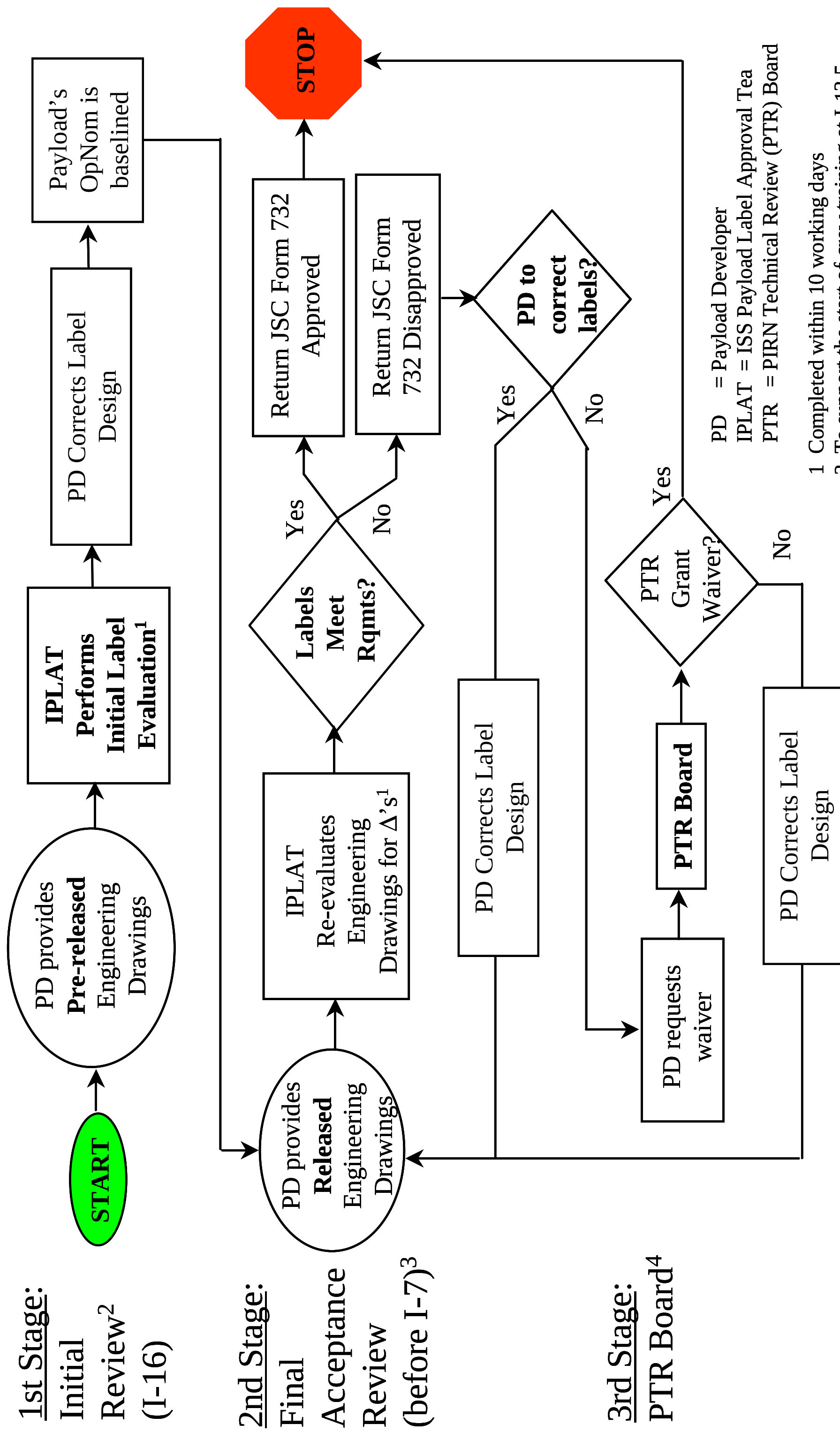
B. Decals: Peel-off labels with adhesive backing that are applied onto hardware.

C. Ink-stamped labels: Markings, stamped with ink, onto the hardware.

D. Engraved or Etched labels: Markings carved onto the hardware surface.

E. Placards: Cards which are inserted into pockets.

F. Any other method of applying markings onto hardware.



1 Completed within 10 working days
2 To support the start of crew training at I-13.5.
3 Supports baselining of procedures at I-7.
4 Only if IPLAT and PD disagree on resolution

FIGURE E-1 IPLAT PAYLOAD LABEL APPROVAL PROCESS

SSP 50005, International Space Station Flight Crew Integration Standard (NASA-STD-3000/T) was used as the basis for the payload labeling guidelines contained herein.

E.2 ISS PAYLOAD LABEL APPROVAL PROCESS

The PD is responsible for providing label drawings, label location drawings and information sufficient to enable IPLAT to determine that the instructions herein are met. The PD will coordinate with IPLAT before submitting the label drawings for approval.

IPLAT is responsible for reviewing all payloads labels, providing guidance to the PD and granting approval based on the instructions herein. IPLAT is also responsible for performing a human engineering assessment of the labels and ensuring the labels are appropriate from a human engineering perspective, including commonality, standardization, and terminology.

The process for obtaining approval of ISS payload labels is shown in Figure E-1. IPLAT performs two evaluations. The initial label evaluation is performed at approximately the I-16 timeframe. This supports the start of crew training at I-13.5. The PD submits pre-released engineering drawings to IPLAT. Less formal materials are acceptable for this first review if they contain enough information for IPLAT to perform the evaluation. Upon receiving the drawings, or other materials, IPLAT has 10 working days to complete the evaluation. IPLAT will return a checklist that documents any requirement violations, and suggested solutions. The PD will then update the label designs based on IPLAT's recommendations.

The final label evaluation is to be completed before I-7, enabling the payload to meet the I-7 deadline for final procedures review and baselining, followed by shipping of flight hardware to KSC by L-6. Before this final evaluation, the payload's Operations Nomenclature (OpNom), must be baselined. The PD submits released engineering drawings to IPLAT. IPLAT has 10 working days to complete this final evaluation. If the labels meet the requirements, IPLAT returns JSC Form 732, approved, to the PD. Form 732 is the PD's official verification that the labels meet the requirements, and should be included in the payload's verification record. If the labels still do not meet the requirements, the PD will correct the label design per IPLAT's recommendations.

The PTR is responsible for resolving issues and disagreements between the PD and IPLAT.

Once final approval has been granted via Form 732, the PD can manufacture labels, or order labels from the Decal Design & Production Facility (DDPF) via JSC Form 733.

E.3 IPLAT APPROVAL INSTRUCTIONS

IPLAT will use the following instructions in reviewing and providing the approval of payload labels.

E.3.1 GROUND ASSEMBLY AND HANDLING

Labels used for ground assembly and handling must not interfere with on-orbit crew interface labeling. Product marking for ground assembly and handling should be in accordance with MIL-STD-130, Section 4, except paragraph 4.1.c.

E.3.2 FUNCTION CONSIDERATIONS

A. Decals and placards must contain information required by the user regarding the purpose, the function, and/or the functional result of the use of equipment items. Engineering characteristics or nomenclature may be described as a secondary consideration.

B. Instrument decals and placards, for example, should be labeled in terms of what is being measured or controlled. Calibration data may be included where applicable.

E.3.3 PAYLOAD ORIENTATION

A. Payload labeling, displays, and controls must have a consistent rack vertical orientation arrangement with the rack vertical axis origin at the bottom of the rack hinge point.

B. Payload labels required for operations with the rack(s) rotated should be oriented with respect to required crew positions.

E.3.4 DELETED (MOVED TO E.3.5.4.1)

E.3.5 LABELING DESIGN

E.3.5.1 Labeling Standardization

A. Standard decals needed by the PD which are available in JSC 27260, Decal Process Document and Catalog, must either be obtained from the DDPF, or designed to be identical to them. Examples of labels found in the catalog are: IMS, fire hole, toxicology, hazardous, caution and warning, rack power switch, fire indicators, cable/hose labels, etc. The DDPF is also available to PDs for fabricating labels not found in JSC 27260.

B. Labeling must be standardized between and within systems.

C. Deleted.

D. Operations Nomenclature (OpNom)

(1) Non-IMS Hardware Labels - Nomenclature on all non-IMS hardware labels must conform to the operational nomenclature guidelines for content (characters used) provided in SSP 50254, Operations Nomenclature. The format for these labels is upper case, as required in paragraph E below.

(2) IMS Labels - When nomenclature is used above the bar code of an IMS label:

a. Such nomenclature must conform to SSP 50254 guidelines for both content and format (mixed case).

b. Such nomenclature must match the nomenclature on the hardware label, except that IMS label text is in mixed case, and hardware label text is in upper case.

E. Label Text

(1) Upper Case - Labels for equipment, displays, controls, switch positions, connectors, cables/hoses, LEDs, stowage containers, etc., must be listed in upper case letters only. This includes abbreviations and acronyms.

(2) Payload Name labels

a. Spelling Out vs. Acronyms - The name label for the main unit of a payload must spell out the name, followed by the acronym in parentheses, even if the acronym is an approved OpNom. The OpNom acronyms may then be used on all subordinate equipment. For example, the rack for SRF should spell out “SCIENCE RESEARCH FACILITY (SRF)”. All subordinate equipment may then use the SRF acronym.

b. Font size for name labels - The font size for the name label of an item should not be less than 12 point.

(3) Title nomenclature must be consistent with procedural handbooks and checklists.

F. General To Specific Principle - More general, or important information should be placed above or to the left on a label(s). Increasingly more specific, or less important information should be placed lower or to the right, with the most specific, least important information on the bottom or furthest right.

G. Keypads - Non-COTS keypads on payloads should use mixed case (upper and lower case) letters.

E.3.5.2 Readability

A. Decals and placards should be as concise and direct as possible.

B. Abbreviations

(1) Deleted

(2) Periods should be omitted except when needed to preclude misinterpretation.

C. Decal and Placard Life

Payloads must provide labels that are readable for the duration of the payload's operation, which are replaceable.

D. Language

(1) Decals and placards must be written in the English language.

(2) If dual languages are used, English must be used first and with lettering at least 25% larger than the secondary language.

E. Decals and placards should be designed so as to minimize visual clutter.

F. Illumination - Labels and markings should be designed to be read at all general illumination levels and color characteristics of the illuminant as specified in Table 3.12.3.4-2.

G. Displays and Controls Title Selection

(1) Physical Hardware - When verbs are used to label physical hardware (buttons, switches, controls, etc.), the present tense should be used. For example: OPEN or CLOSE, BEGIN, or END, START or STOP, etc.

(2) Physical Hardware Linked to Software Displays - If physical hardware is linked to and/or represented by software displayed data or controls (i.e. Liquid Crystal Display (LCD)), the labels for the physical hardware and the software representation must use the same terminology.

E.3.5.3 Label Placement

A. All labels must be placed on the payload hardware in accordance to the label location drawings.

B. Payloads Operated From Rack Front Panels - Payloads operated from the front panel of racks must be labeled in accordance to Figure E-2.

(1) Rack IMS Label - The rack IMS label must be located on the top left corner of the rack.

(2) Rack Name Label

a. The rack name label must be located to the right of the rack IMS label.

b. The rack name label must spell out the name of the rack. The acronym, if applicable, should follow in parentheses. The acronym may then be used on all subordinate equipment.

c. The font size of the rack name label should be the largest one for the entire rack, at 48 point font, minimum.

(3) Subrack IMS Label - The subrack IMS label must be located on the top left corner of the subrack drawer.

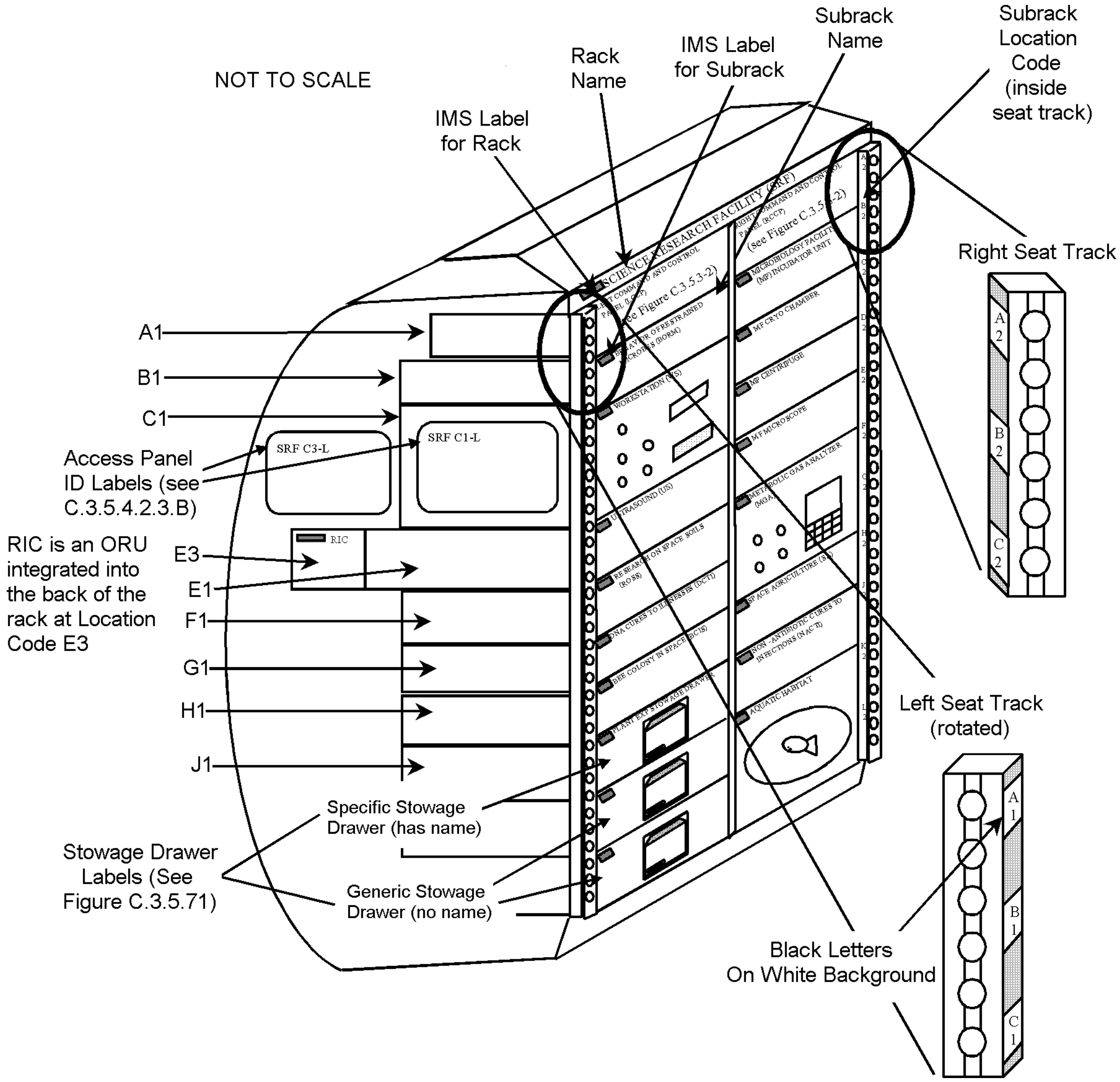
(4) Subrack Name Label

a. The subrack name label must be located to the right of the subrack IMS label.

b. The subrack name label must spell out the name of the subrack. The acronym, if applicable, should follow in parentheses. The acronym may then be used on all subordinate equipment.

- If this subrack is part of a facility rack (i.e. HRF, MSG, FCF, etc.), and will never be relocated into another rack, then the subrack name label need not include the facility's acronym (e.g. "WORKSTATION", as opposed to "HRF WORKSTATION").

- If there are several related subracks that are considered a "sub-facility", the first such subrack must spell out the name of the sub-facility. The remaining subracks may use the acronym if they are co-located and below this subrack. For example, in Figure E-2, MICROBIOLOGY FACILITY is the name of the sub-facility, and is spelled out on the first subrack (in location B2), with the



Rack IMS Label - Located on the top left corner of the rack.

Rack Name Label - Located to the right of the rack IMS label. Must be spelled out (48 point font minimum), with acronym following in parenthesis. All subordinate equipment may then use the acronym.

Subrack IMS Label - Located on the top left corner of th subrack drawer.

Subrack Name Label - Located to the right of the subrack IMS label. Must be spelled out (between 28-36 point font), wit acronym following in parentheses. All subordinate equipment may then use the acronym.

Subrack Location Code - Located on the inside of the seat track. Letters A through N, excluding I (18 point font). Letter/number pairs must be placed at intervals equal to the individual rack's smallest drawer unit (e.g., 4 PU (7 inches) for U.S. payloads, different for IP racks).

NOTE: In above figure, MF is a sub-facility within SRF comprised of four subracks (B2 through E2). The name is spelled out on the first subrack. The acronym is then used on subsequent subracks.

FIGURE E-2 RACK LABEL PLACEMENT

acronym following in parentheses. The remaining subracks only use the acronym.

c. The font size of the subrack name label should be smaller than the rack name label, between 28 and 36 point.

C. Payloads Not Operated From Rack Front Panels - This section applies to all self-contained payloads other than those controlled from front panels (mounted elsewhere, not on the face of a rack like subrack payloads). Examples: SAMS-II Remote Triaxial Sensor System, HRF Phantom Torso and DOSMAP, etc. See Figure E-4.

(1) The IMS label should be placed in the upper left corner of the dominant face of the payload.

(2) Payload Name Label

a. The payload name label should be placed to the right of the IMS label.

b. The payload name label must spell out the name of the payload if it is considered the main unit. The acronym, if applicable, should follow in parentheses. The acronym may then be used on all subordinate equipment.

c. The font size of the payload name label should be the largest one for the entire payload.

D. Loose Equipment

(1) The IMS label should be placed in the upper left corner (if there is one) of the dominant face of the item. If there is no upper left corner, place the IMS label either to the extreme left (See Example L of Figure E-4), or at the top of the dominant face.

(2) Name Label

a. If the dominant face of the item is populated with controls, the name label should be placed immediately to the right, or below the IMS label. If the dominant face is blank (such as a binder or stowage bag, as in Example B of Figure E-4), then the name label should be placed in the center of the face.

b. Small Items - In the case of very small equipment items, an IMS label with the equipment’s name in the text portion above the bar code is sufficient to satisfy both the IMS and Name label requirements.

E. Control Panel Labels

(1) Positions - Labels must be centered above connectors, switches, LEDs, displays, controls, etc. Labels may be placed in other locations when they cannot dimensionally fit in the required location, or if they would be obstructed by items like cables and hoses, or to preclude misassociation with adjacent items.

(2) Size - Labels for controls on a panel should be smaller than the name label for the panel, and should be between 10 and 20 point font. Different levels of controls should be graduated in size. For example, grouping label titles should be larger than the labels for the controls within them. Similar levels of controls should be the same size. See Figure E-3 for examples.

F. Part Number and Serial Number Labels - Part number and serial number labels should be placed together for ease of identification. The part number label should be arranged to the left or above the serial number label. P/N and S/N, which are the standard OpNom representations of part number and serial number, respectively, should be used.

G. Orientation - All markings and labels must be oriented with respect to the local worksite plane so that they read from left to right. Vertical orientation, with letters arranged vertically if the text is short (e.g. DATA J3), or rotating the label 90 degrees when the text is long (e.g. PAYLOAD ELECTRONICS MODULE), is permissible when the marking or label does not fit in the required orientation.

H. Visibility - Labels must be placed on equipment so that they are visible when the equipment is used or accessed. Markings should be located such that they are perpendicular to the operator's normal line of sight whenever feasible and should not be less than 45 degrees from the line of sight.

I. Overhead Panels - On overhead panels, markings and labeling must be oriented such that they appear upright when observed from local vertical.

J. Association Errors - The arrangement of markings on panels should protect against errors of association of one marking or set of markings with adjacent ones.

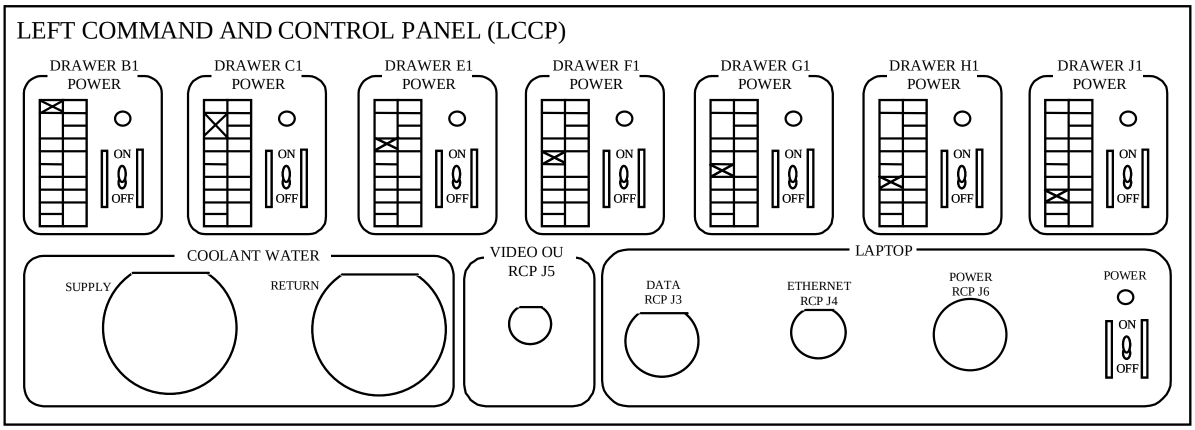
E.3.5.4 Equipment Labeling

E.3.5.4.1 Equipment Identification

A. All items on a payload must be identified with a label, including, but not limited to: displays, controls, switches, connectors, LEDs, containers, vents, etc., such that these items can be clearly referenced in crew procedures. Only those items whose use is

NOT TO SCALE

This panel is at the A1 position in Figure E-2



This panel is at the A2 position in Figure E-2

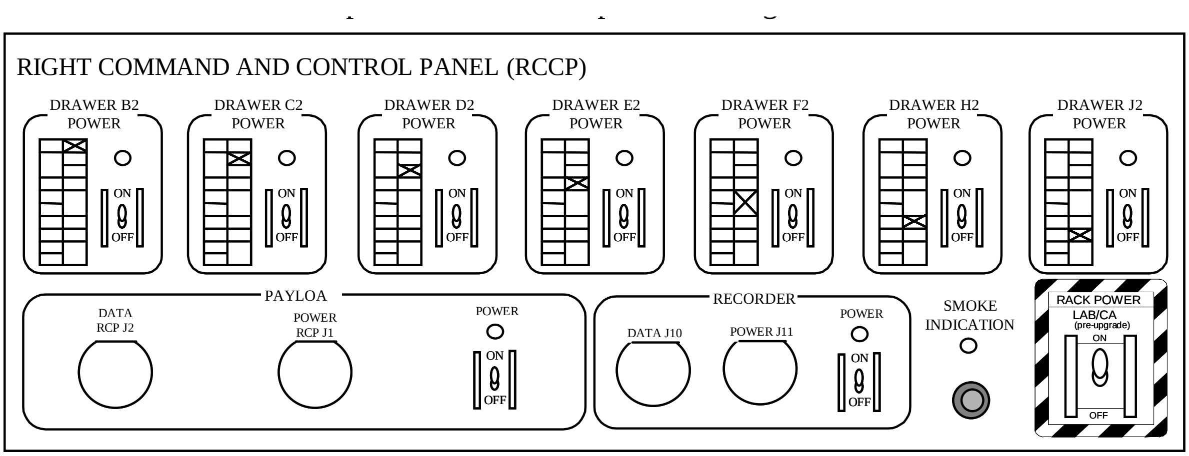


FIGURE E-3 CONTROL PANEL LABELING

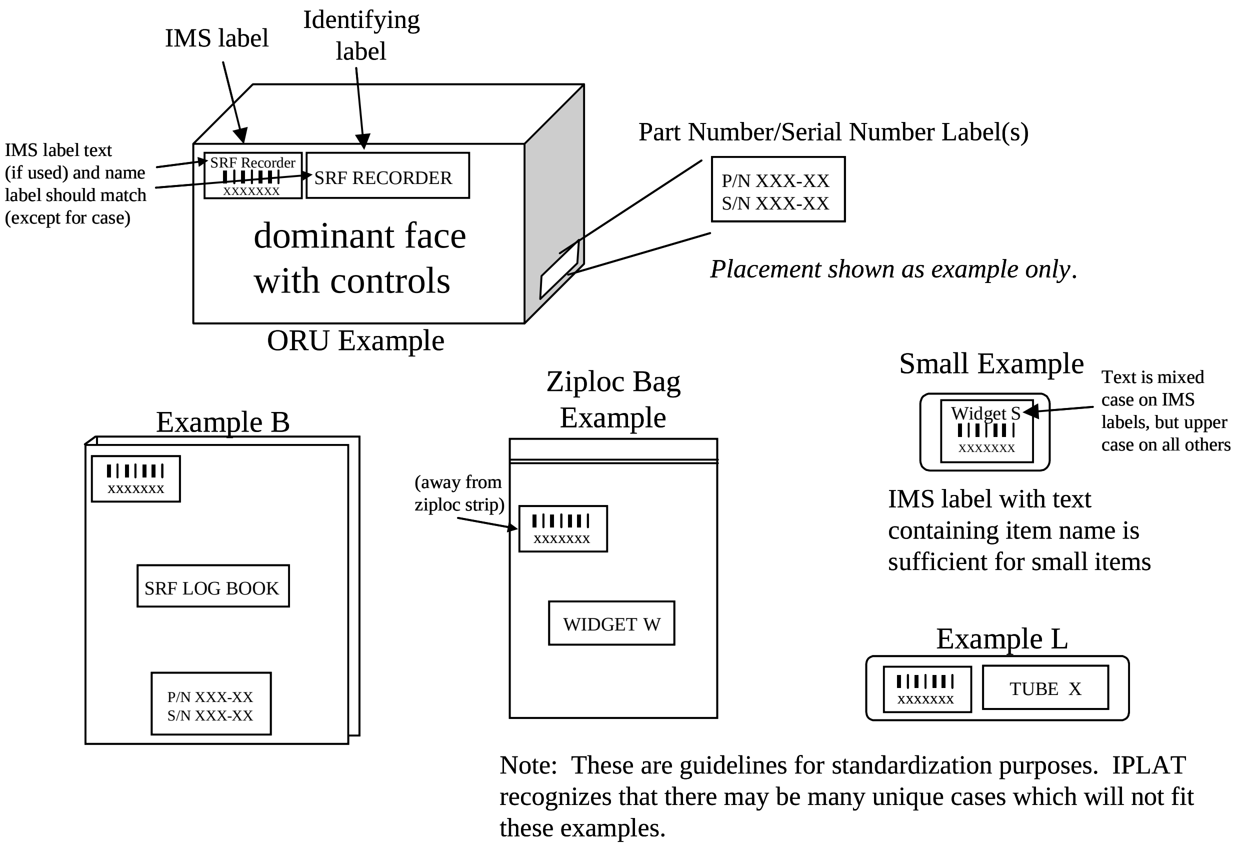


FIGURE E-4 MISCELLANEOUS LABEL PLACEMENT GUIDELINES

obvious to the crew (e.g., food table, windows, etc.) are exempt from this instruction. The font size for these labels must be smaller than the main label naming the payload (see Figure E-4).

B. Containers must be labeled to identify their contents.

C. Loose equipment must be marked with nomenclature that describes the function of the item and its pertinent interfaces.

D. Multi-quantity Items

(1) Multi-quantity items that require individual distinction but are not serialized must be individually numbered. Controls level items should be logically numbered/lettered left to right or top to bottom in descending order (e.g. “DRIVE A”, “DRIVE B”, “DRIVE C”).

(2) Serial Numbers - Multi-quantity items that are serialized should display the serial number as part of the identification.

(3) Containers containing multiple quantities of the same item should use a number in parentheses, after the name, to indicate the quantity (i.e. “TEST TUBES (4)”, indicates there are four test tubes in the container).

E. Logos - If organizational or commercial logo(s) are used, they must not be distracting to the crew while operating the payload. For front panels, the size of a logo should be smaller than the main name label.

E.3.5.4.2 Equipment Coding

E.3.5.4.2.1 Cable and Hose Labeling

A. Crew Interface Cables and Hoses Definition - Electrical cables and hoses which are intended to be interfaced with by the crew for nominal operations (e.g. experiment operations), planned maintenance (e.g. ORU replacement), or are designed to have a crew interface in the event of a contingency situation, are considered crew interface cables and hoses, and are subject to the format requirements below.

B. Crew interface cables and hoses must be labeled to indicate the equipment to which they belong and the connectors to which they mate.

(1) Electrical Cable End Plugs and Corresponding Electrical Connector Ports

a. The cable end plug must be designated with a “P” (e.g. P1), regardless of gender.

b. The connector port on the hardware must be designated with a “J”, regardless of gender, and should be preceded by a descriptive name (e.g. DATA J1 or POWER J2).

c. The plug number and receptacle number for a mating pair should be identical (e.g. P1 mates with J1), except when not possible because a cable is generic.

(2) Cable and Hose Label General Characteristics

a. Font Size - The font size of the text on these labels should be 12 point preferred, or 10 point minimum.

b. Text/Background Color - The text should be black on a white background.

c. Abbreviations - When long names would result in an unreasonably large label, text can be abbreviated.

d. Continuation Lines For Long Names - Long names are discouraged, but if necessary, additional lines can be added to the cable/hose identification and ends labels described below.

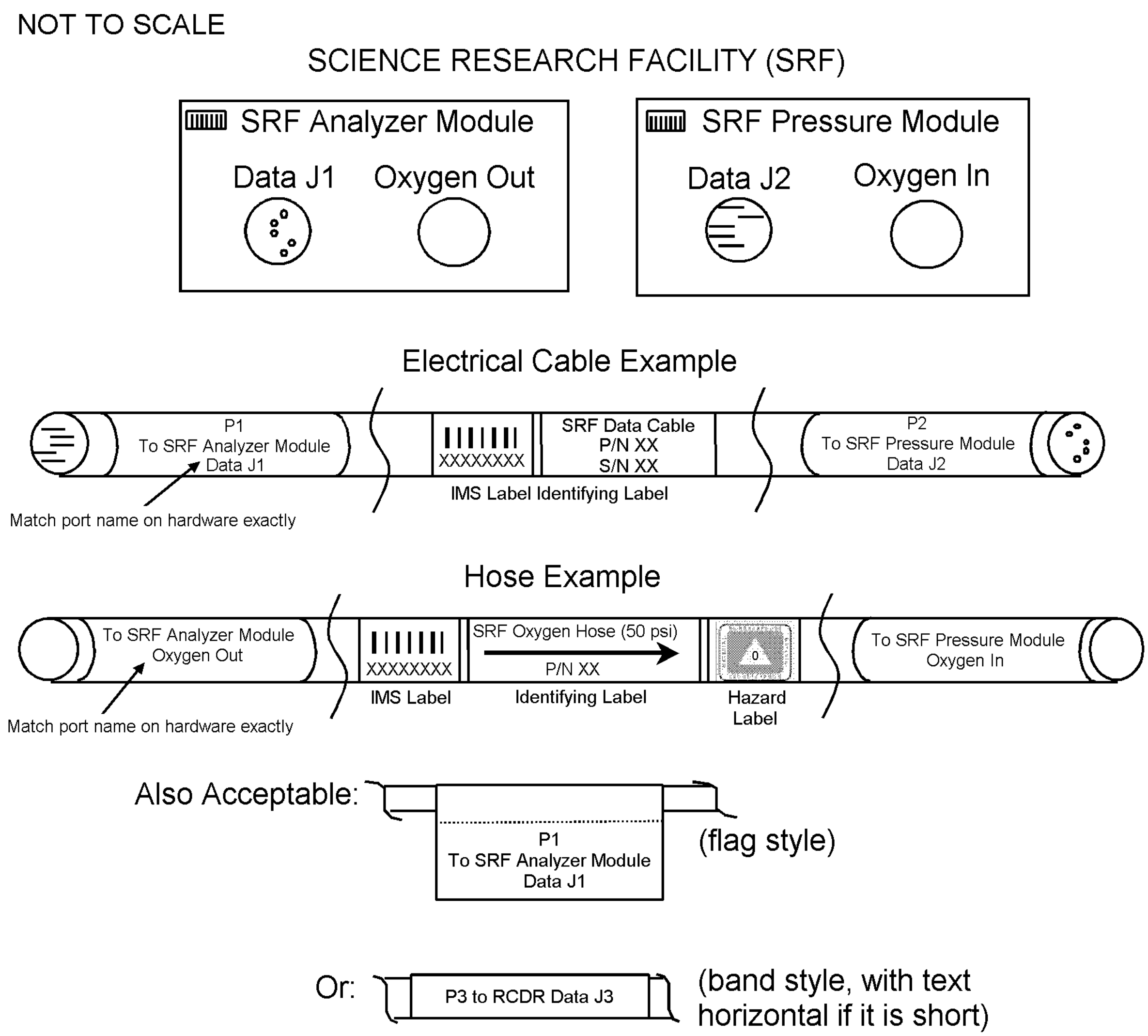
(3) Cable and Hose Identifying Labels - Cables and hoses must contain a main identifying label with the information below. This label must be placed at the mid-length position of the cable/hose, or at intervals not to exceed two meters for long utility lines. See Figure E-5 for examples.

- The name of the cable/hose. For a hose, if the pressure is known and constant, it should be indicated in parentheses after the name (e.g. psi). The flow direction should be indicated with an arrow below the name if the hose ends are not interchangeable.
- The Part number of the cable or hose
- The Serial number of the cable or hose (if applicable)

(4) Cable and Hose IMS Labels - A cable/hose must contain one (and only one) IMS label. It must be placed to the left of the main identifying label, at the mid-length position, as shown in Figure E-5. If the cable/hose requires multiple main identifying labels spaced at two meter intervals per #3 above, the IMS label should be placed at the center of the line.

(5) Cable and Hose End Labels - Labels at the terminal ends of cables/hoses must contain the information below. Vertical order, center justified, is the preferred arrangement. When the circumference of the cable/hose is too small to accommodate a label that wraps around the line with text arranged vertically, a flag style label should be used. For cases where wear and tear of such flag is a concern (i.e. through frequent use), a horizontal arrangement of the information is allowed as long as the text is short. See Figure E-5 for cable/hose label examples.

a. First Line: The name of this end of the cable/hose (e.g. for cables, P1). For a hose, if the end does not have a specific identifier, this line may be left off. If the hose end needs to have a unique identifier, do not use a “P” number (“P”s are reserved for cables).



NOTES:

1. Electrical Cables/Ports – "P" designates cable end plugs and "J" designates receptacles on hardware regardless of gender (pins/sockets).
2. Hose End Labels – The first line of the end label may be left off (as shown above) if the hose end does not have a specific identifier. In this case, only the second and third lines are needed. If hose ends must be identified do not use a "P" number.
3. Hose Identifying Labels – Pressure should be indicated only if it is constant. Flow direction should be shown if the hose ends are not interchangeable.

FIGURE E-5 CABLE AND HOSE LABELING

b. Second Line: The word “TO” followed by the name of the piece of equipment to which this end of the cable/hose mates with. If this end can interface to multiple connector ports (e.g. generic cables), this line may be left off.

c. Third Line: The exact name of the receptacle on the hardware that this end of the cable/hose mates with (e.g. DATA J1 or OXYGEN OUT). If this end can interface to multiple connector ports (i.e. generic cables), this line may be left off.

(6) Hose Hazard Labels - Hoses must have standard hazard class decals indicating the appropriate hazard level for the substance transported through the hose. This label must be placed to the right of the identifying label.

E.3.5.4.2.2 Color Coding

A. Red must only be used to mark emergency use items. Yellow must only be used to mark Caution and Warning items. See Section E.3.5.9 for Caution & Warning labeling requirements.

B. Hazard Labels - Hazard labels have their own, unique coding scheme, of which color is one factor. See Section E.3.5.9.I for instructions.

C. Identification/Connectivity - Color coding used for component identification or to denote connectivity relationships must combine color with nomenclature (i.e. hardware name and the payload it belongs to, simple number, part number, etc.) such that when those components are referred to within procedures, it is clear which components the procedures are referring to. The only color restriction is listed in paragraph A (red and yellow cannot be used).

D. Color Difference

(1) Only one hue within a color category (e.g., blues, greens) should be used on the decals or placards within the same integrated rack.

(2) That color must always be associated with a single meaning within the same system or integrated rack.

E. Number of Colors - No more than nine colors, including white and black, must be used in a coding system.

F. Markings/Background Color - Markings and background colors on labels must have sufficient contrast such that the labels are readable in ambient ISS lighting conditions.

Labels should adhere to the accepted combinations of markings and background color listed below:

Markings	Background
Black	White
Black	Yellow
Black	Silver (metalphoto labels)
White	Black
White	Red
White	Grey
Yellow	Blue
Red	White
Blue	Yellow

E.3.5.4.2.3 Location and Orientation Coding

A. Subrack Location Codes:

(1) At the Rack Level - Subrack location codes must be placed along the inside surface of the seat track at intervals equal to the individual rack's smallest drawer unit (e.g: 4 PU (7 inches) for U.S. payloads, different for IP racks), as shown in Figure E-2. Each letter/number pair must be 18 point font and placed at the top of the particular drawer interval. Locations other than the inside of the seat track are permissible only if there is a permanent obstruction that would cover the labels.

(2) For Control Panels That Control Multiple Subracks - Each subrack's controls must be mapped to its location using the letter/number code (e.g. "A1", "A2", "B1", "B2", etc.), and a graphic (matrix with appropriate box checked) showing the individual locker's location in the rack. See Figure E-3 for examples.

B. Access Panels - maintenance access panels must be labeled to assist the crew in locating the panel for maintenance activities.

(1) Access panel identification labels should be located in the upper left corner position on the panel with respect to the local vertical orientation.

(2) Access panel identification labels for access panels on the side or back of a rack must be labeled as in Figure E-2 and include:

a. The acronym for the rack (e.g. SRF).

b. Its height location using the subrack location code (e.g. C3).

c. Its left, right, or back location on the rack preceded by a hyphen (e.g. -L for left, -R for right, -B for back).

For example, a completed access panel label might read SRF C3-L or SRF C3-R.

C. Alignment Marks/Interface Identification

(1) Alignment Marks - Alignment marks or other orientation markings must be used to aid the crew with the installation/mating of equipment when the hardware requires a specific orientation.

(2) Visibility - Alignment marks, arrows, or other labels showing required orientation must be visible during alignment and attachment.

(3) Tethered Equipment - Interface identification should not be used for movable items tethered to a mating part (e.g., dust cap for an electrical connector, hinged lid for a stowage container).

E.3.5.5 Deleted

E.3.5.6 Operating Instruction Labels

Operating instruction labels are hardware labels (affixed to hardware) that contain procedural steps. The procedural text should be coordinated with the PODF prior to final IPLAT approval and conform to ODF standards as documented in ODF Standards, SSP 50253. See Figure E-6 for an example.

A. Location - Equipment operating instructions should be located on or adjacent to equipment.

B. Equipment Name - The instructions should have the title of the equipment to be operated centered above the text.

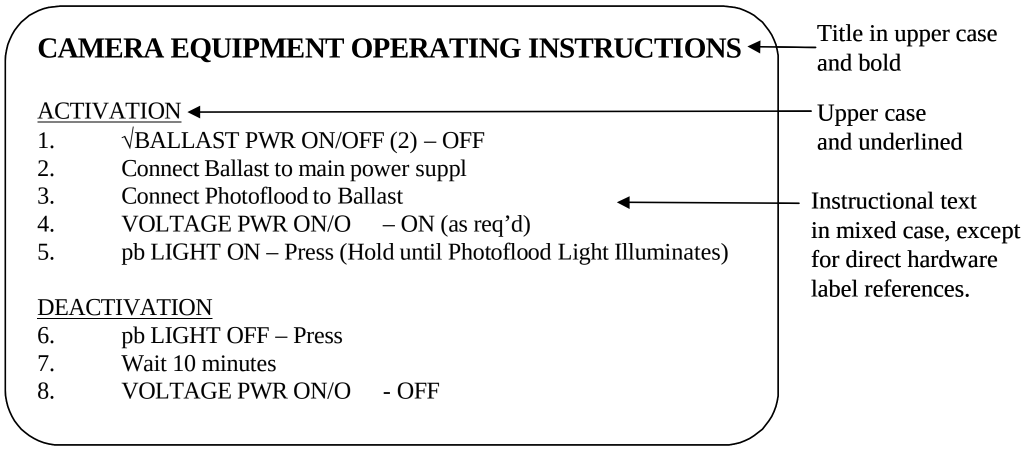


FIGURE E-6 OPERATING INSTRUCTION LABEL EXAMPLE

C. Grouping - Instructions should be grouped and titled by category (e.g., installation, removal, activation, calibration, etc.).

D. Title Selection - The titles of instructional text for equipment, displays, controls, switch positions, connectors, etc., must be in upper case letters only and bold. Title nomenclature must be consistent with procedural handbooks and checklists.

E. Instructional Text - Instructional text below titles must use upper and lower case letters. Direct references to hardware items should be in upper case so they match the hardware labels.

F. Required Tools - Instruction for removal of stowage items should list any tools required prior to the instructional text. When tools are required to remove stowage items, markings should be used for the location of the fasteners to be removed.

E.3.5.7 Stowage Container Labeling

This section applies to stowage containers provided by the payload, located within the payload, not in general ISS stowage containers.

A. Each stowage container must display the contents on its front surface visible to the crewmember.

For drawer, box, or bag style stowage containers that are mounted as subracks as in Figure E-2, the following requirements apply:

(1) The contents label should be as shown in Figure E-7a when the location is known and fixed. The contents label should be as shown in Figure E-7b when the location is not known or is variable.

(2) If the drawer/box/bag is being launched individually in the MPLM or the Space Shuttle Middeck, then the drawer must have the ascent label as shown in Figure E-7c, in the front of the pocket. This label is then removed upon transfer to ISS, revealing the label in Figure E-7a or E-7b.

B. Provisions should be made to permit in-flight revisions to or replacement of stowage labels on all stowage containers.

C. Subdivided Containers:

(1) If a stowage container is subdivided internally into smaller closed containers, the sub-containers must carry a list of contents.

(2) If the available marking space on a sub-container is insufficient to display the complete content titles, a contents list must be displayed elsewhere and clearly identified as belonging to the sub-container.

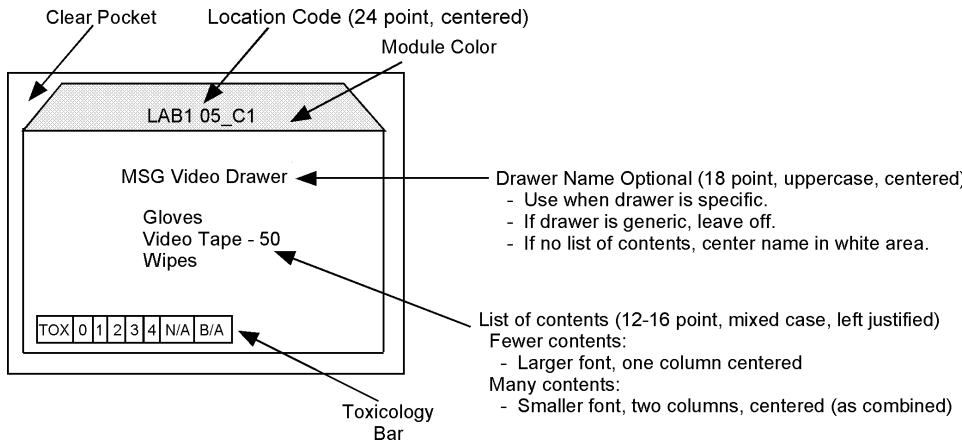
(3) The specific contents of each sub-container must be listed on the front surface of its container or near it.

D. Individual-Crew Items - Items allocated to a specific crewmember should be identified on the listing with the user's title, name, or other coding technique.

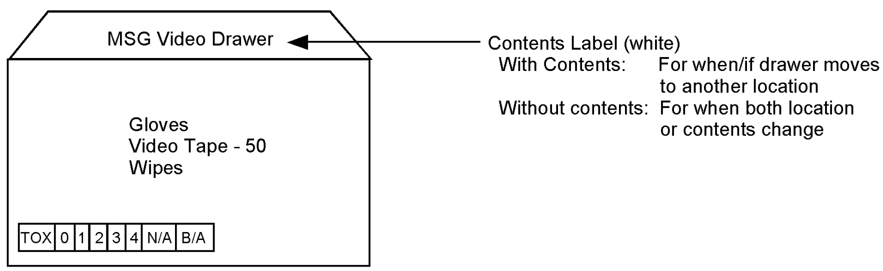
E. Tool/Accessory Kit Labeling - Containers with designated locations for placement of equipment set (e.g., socket wrenches in a tool kit) should have each location identified with the title of the item stowed.

E.3.5.8 Grouped Equipment Items

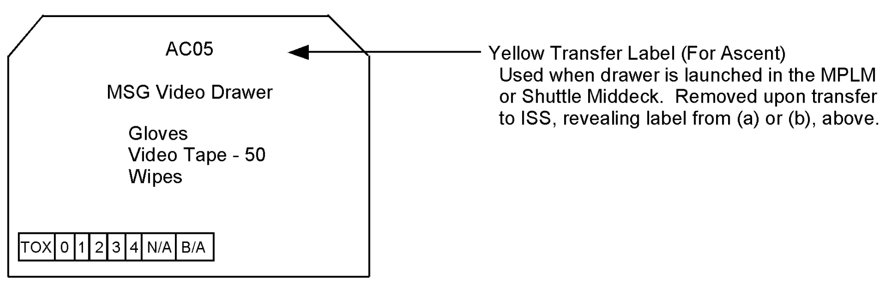
A. Functional groups of three or more equipment items (i.e. displays, controls, switch positions, connectors, LEDS, etc.) must be identified (e.g., by common color, by boundary lines). Functional groups of equipment items are all associated or connected with a common system or purpose. (e.g., CABIN AIR, FURNACE A, EXPERIMENT "M", PANEL LIGHTING). Two functionally related items should be grouped when such grouping provides clarification of purpose and/or distinguishes them from surrounding items. See Figure E-8 for grouping label examples.



a) Standard Drawer Title/Contents Label - With Location Information



b) Standard Drawer Contents Label - Without Location Information



c) Ascent Drawer Contents Label

NOTE: IPLAT must review the proposed label. The PD can thewn order this label from the DDPF. Reference Drawing #SEG32106109, Crew Transfer Bag Standard Label.

FIGURE E-7 STANDARD PAYLOAD STOWAGED DRAWER LABELS

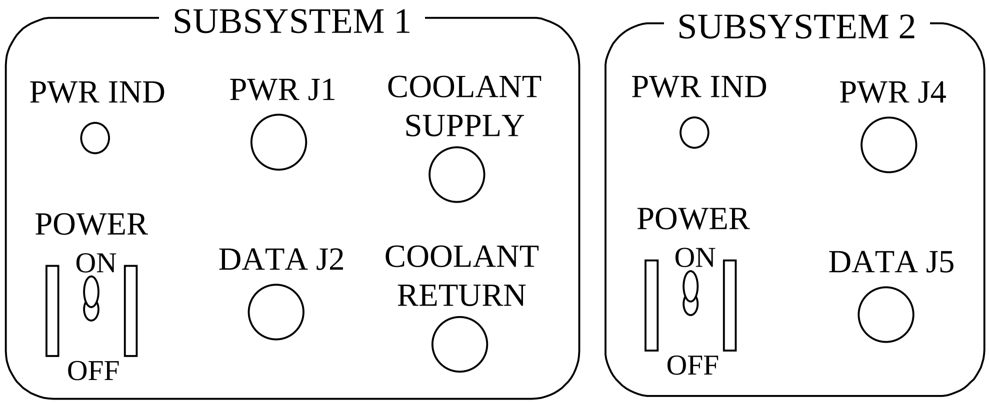


FIGURE E-8 GROUPING LABEL EXAMPLES

B. Labels must be located above the functional groups they identify.

C. When a line is used to enclose a functional group and define its boundaries, the labels must be centered at the top of the group, in a break in the line. When it is not possible to center the text at the top, the text may be placed elsewhere along the perimeter of the boundary line, but local vertical orientation or the text must be maintained.

(1) The width of the line must not be greater than the stroke width of the letters.

(2) The line must form an enclosed rectangle, or box, with rounded corners. Deviations from the rectangular shape are allowed when dimensional restrictions preclude a perfect rectangle.

D. When displays and controls are used together in adjustments or activation tasks, visible labels or markings must indicate their functional relationships.

E.3.5.9 Caution and Warning Labels

Caution and warning labels are required for indicating potentially undesirable conditions. See Figure E-9 for examples.

A. Caution and warning labels must be standardized between and within systems.

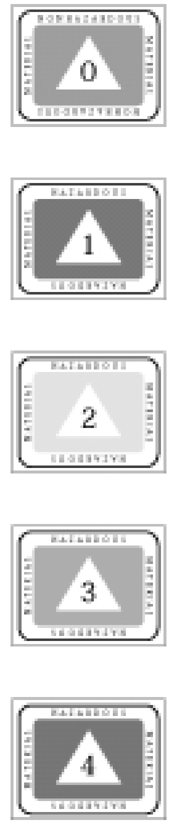
B. Caution and warning labels must be distinct from one another.

C. Caution and warning labels must identify the type of hazard and the action that would prevent its occurrence.

D. The caution and warning markings must be located in a visible area.

Emergency Label Example

Caution/Warning Label Example



Toxic Hazard Label Examples

FIGURE E-9 CAUTION AND WARNING LABEL EXAMPLES

E. Emergency-Use Label Specifications

(1) Labels on emergency-use items (e.g., repair kits, emergency lighting, fire extinguisher, etc.) must be surrounded by diagonal red and white stripes either on the item or adjacent to it.

(2) The emergency type warning stripes must be alternate red and white.

(3) The red and white stripes should be of equal width.

(4) There must be no fewer than four red stripes and three white stripes.

(5) The striping must be applied at a 45 degree angle rotated clockwise from the vertical.

(6) The striping must begin and end with a red stripe.

(7) The text must be white letters on the red background or red letters on a white background.

(8) For items located within a storage container, the diagonal striping must be applied to the door of the container and the titles of the emergency items must be included on the marking.

F. Caution And Warning Label Specifications

(1) Caution/warning decals and placards must be surrounded by diagonal yellow and black stripes.

(2) The caution/warning type stripes must be alternate yellow and black.

(3) The yellow and black stripes should be of equal width.

(4) There must be no fewer than four yellow stripes and three black stripes.

(5) The striping must be applied at a 45 degree angle rotated clockwise from the vertical.

(6) The striping must begin and end with a yellow stripe.

(7) The text must be black letters on the yellow background.

G. Switches and Buttons

(1) The striping around a switch or button should not be wider than 25mm (1 in) or narrower than 3 mm (0.125 in).

(2) If one side of a switch or button has less than 3 mm (0.125 in) space, no striping should be applied to that side.

H. Deleted.

I. Hazard Labels

(1) Chemicals - The standard hazard class decals must be used to identify the proper hazard class of payload chemicals (i.e. chemicals in solid, liquid, or gaseous states), as deemed by the payload's toxicology representative. The developer may obtain these decals from JSC 27260, Decal Process Document and Catalog, or must produce identical labels. See NSTS 07700, Volume 14, Appendix 9, Section 5.6.3 for hazard class definitions.

(2) Other hazards - When biological, radiation, sharps, battery, or other hazards are identified by safety personnel, the appropriate standard label (if available)

must be applied in a prominent location. The developer may obtain these decals from JSC 27260, Decal Process Document and Catalog, or must produce identical labels.

E.3.5.10 Alphanumeric

E.3.5.10.1 Font Style

A. The font style used on decals, placards, and labels must be Helvetica or Futura demibold. If there are fit problems:

The use of condensed type (Helvetica Condensed) or abbreviations is the preferred method of solving line length.

However, for engraved markings which are not able to exactly match the above required font, the engraved marking should match the Helvetica font as nearly as possible.

Note: Helvetica is the preferred font.

B. Stenciled Characters - Stencil-type characters should not be used on display/control panels or other equipment.

E.3.5.10.2 Punctuation

A. Periods and Commas - Periods (.) and commas (,) should not be used in equipment labels, except to preclude misinterpretation.

B. Hyphens - Hyphens (-) should not be used in equipment labels, except in part and serial numbers and to preclude misinterpretation.

C. Parentheses and Ampersands - In general, parentheses and ampersands should not be used on payload equipment. Parentheses may be used to enclose acronyms after spelled out names (See Section E.3.5.3) and to designate multiple quantities of an item (See Section E.3.5.4.1.D.3). Ampersands may be used where the substitution of slashes (/) would remove or distort the intended meaning (i.e. PUSH & HOLD vs. PUSH/HOLD).

D. Slashes - The slash (/) may be used in place of the words “and” and “or” and may be used to indicate multiple functions.

E.3.5.10.3 Special Character

A. Subscript and Superscript Size - Subscripts and superscripts should be 0.6 to 0.7 times the height of associated characters.

B. Subscripts - Numeric subscripts and upper case letter subscripts should be centered on the baseline of associated characters.

C. Lower Case Letter Subscripts -The base of lower case letters and the ovals of g, p, q, etc., should be at the same level as the base of adjacent capital letters.

D. Degree Symbol - The degree symbol should be centered on an imaginary line extended from the top of the F or C symbols.

E. Pound or Number Symbol (#) - The pound or number symbol should be centered on an imaginary line extended from the top of the associated numerals and placed two stroke widths away from them.

E.3.5.10.4 Character Height

A. Character Height - Character height depends on viewing distance and luminance level. At a viewing distance of 710 mm (28 in), the height of letters and numerals should be within the range of values given in Table E-I.

B. Variable Distance - For a distance (D) other than 710 mm (28 in), multiply the values in Table E-I by D/710 mm (D/28 in) to obtain the appropriate character height.

C. Size Categories - Characters used in hierarchical labeling (e.g. rack name, subrack name, controls groupings, port names, etc.) should be graduated in size. There should be at least a 25 percent difference in the character height between each of these categories.

D. Space Limitations - The use of the same size letters and numerals for all categories on a label is acceptable for solving space limitation and clarity problems. The height of lettering and numerals should be not less than 3 mm (0.12 in).

E.3.5.10.5 Character Width

A. Letters - The width of letters should be 0.6 of the height, except for the letter “I,” which should be one stroke in width, the letters “J” and “L”, which should be 0.5 of the height, the letter “M”, which should be 0.7 of the height, and the letter “W,” which should be 0.8 of the height.

TABLE E-I CHARACTER HEIGHT - 710 MM (28 IN) VIEWING DISTANCE

Markings	Character Height	
	3.5 cd/m^2 (1ft-L) or below	Above 3.5 cd/m^2 (1ft-L)
For critical markings, with position variable (e.g., numerals on counters and settable or moving scales)	5-8 mm (0.20-0.31 in)	3-5 mm (0.12-0.20 in)
For critical markings, with position fixed (e.g., numerals on fixed scales, controls, and switch markings, or emergency instructions)	4-8 mm (0.16-0.31 in)	2.5-5 mm (0.10-0.20 in)
For noncritical markings (e.g., identification labels, routine instructions, or markings required only for familiarization)	1.3-5 mm (0.05-0.20 in)	1.3-5 mm (0.05-0.20 in)

B. Numerals - The width of numerals should be 0.6 of the height, except for the numeral “4”, which should be one stroke width wider and the numeral “1”, which should be one stroke in width.

C. Wide Characters - When wider characters are used on a curved surface, the basic height-to-width ratio should be increased to 1:1.

E.3.5.10.6 Stroke Width

A. Height-to-Stroke Ratio - Marking letters and numerals should have a height-to-stroke ratio of 5:1 to 8:1.

B. Transillumination Background - Opaque markings on a transilluminated lighted background should have a height-to-stroke ratio of 5:1 to 6:1.

C. Transilluminated Markings - Transilluminated markings on a dark background or markings used on integrally lighted instruments should have a height-to-stroke ratio of 7:1 to 8:1.

D. General Purpose Illumination - Characters used on display panels and equipment when viewed under general purpose flood lighting or normal display conditions as specified in Table 3.12.3.4-2 should have a height-to-stroke ratio of 6:1 to 7:1.

E.3.5.10.7 Character Measurement

A. Measurement - All letters and numeral measurement should be made from the outside edges of the stroke lines for other than machine engraving on opaque surfaces.

B. Engravings - For all mechanical engraving on opaque surfaces, the dimensions controlling the size of letters and numerals should be measured from centerline to centerline of the stroke.

E.3.5.10.8 Space

A. Character Spacing - The spacing between letters within words and between digits in a multi-digit number should be the equivalent of one stroke width between two straight-sided letters such as H and l. (This instruction intended to accommodate the normal commercial typographical practice of spacing letters to achieve a, consistent visual continuity. This permits close spacing of open letters such as C and T to avoid large apparent gaps.)

B. Word Spacing - The spacing between words should be the equivalent of the letter W between two straight-sided letters such as N and F.

C. Line Spacing

(1) The spacing between lines of related text should be 0.5 of upper case letter height.

(2) Spacing between headings and text should be 0.6 to 1.0 of upper case letter height.

E.3.5.11 Bar Coding

PDs will coordinate with NASA/JSC organization OC for Inventory Management System (IMS) label registration.

A. Racks, subracks, stowage trays, loose equipment, consumables, and ORUs must have an inventory management label in accordance with SSP 50007. IMS labels, or their placeholders, must be present on engineering drawings. If the PD orders their IMS labels from the DDPF, the decal catalog decal part number should be included in a note on the engineering drawing.

B. Deleted.

C. Deleted.

E.3.6 SCALE MARKING

A. Accuracy

(1) The precision of scale marking should be equal to or less than the precision of the input signal.

(2) In general, scales that are to be read quantitatively to the nearest graduation mark should be designed so that interpolation between graduation marks is not necessary. Interpolation should be limited to one half the distance between minor graduation marks.

(3) Scales should have a zero reference.

(4) If precise measurements are needed, scale graduation marks should be marked clearly to allow for unambiguous measurements.

B. Interval Values

(1) The graduation intervals should progress by one, five, or two units of decimal multiples thereof, in that order of preference.

(2) The number of graduation marks between numbered graduation marks should not exceed nine.

C. Scale Markings (High Luminance - above 1 ft-L)

(1) The minimum width of major, intermediate, and minor marks should be 0.32 mm (0.0125 in)

(2) The length of major, intermediate, and minor graduation marks should be at least 5.6 mm, 4.1 mm, and 2.5 mm (0.22, 0.16, and 0.09 in), respectively.

(3) The minimum distance between major graduation marks should be 13 mm (0.5 in).

(4) Minor graduation marks may be spaced as close as 0.89 mm (0.035 in), but the distance should be at least twice the stroke width for white marks on black dial faces and at least one stroke width for black marks on white dial faces.

D. Scale Markings (Low Luminance - below 1 ft-L)

(1) The minimum width of a major graduation should be 0.89 mm (0.035 in), the minimum width of an intermediate graduation should be 0.76 mm (0.030 in), and the minimum width of a minor graduation should be 0.64 mm (0.025 in).

(2) The length of major, intermediate, and minor graduation marks should be at least 5.6 mm, 4.1 mm, and 2.5 mm (0.22, 0.16, and 0.10 in), respectively.

(3) The minimum distance between major graduation marks should be 16.5 mm (0.65 in).

(4) Graduation marks should be spaced a minimum of 1.5 mm (0.06 in) between centerlines.